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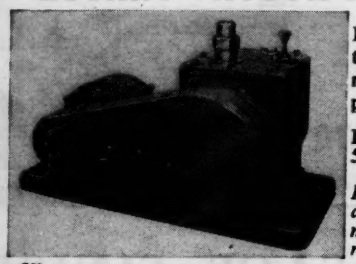

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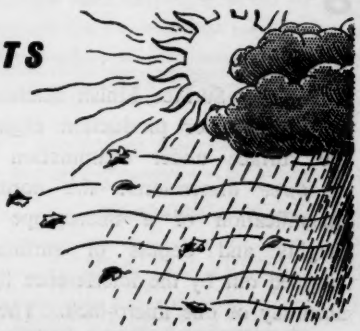

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CHURCHILL COLLEGE, CAMBRIDGE

SINCE the Second World War, there has been an increasing recognition that the welfare of nations, and in particular their economic strength, depends largely on their success in the application of science and the results of scientific research to industry and agriculture. With this recognition has come an awareness that the world is suffering from a shortage of people trained in science and technology on whom the burden of progress must fall. This shortage has been widely publicized in Britain, and it affects us very seriously for, as a nation, we depend largely on our export trade to maintain our standard of living and our position as a Great Power. In the fierce competition of international trade, we can only survive if we use to the full our talents in science and technology, and seek to change continually the pattern of our industry by the introduction of new products and new processes.

The most recent estimate made by the Scientific Manpower Committee of the Advisory Council on Scientific Policy (Cmnd. 278) suggests that, to meet foreseeable needs, we must double our present output of scientists and technologists by 1970. That this is possible, numerically speaking, is not in serious doubt. Quite apart from the effect of the increased post-war birth-rate on over-all numbers, there is now evident an increasing tendency for children to extend their school education beyond the age of sixteen, and a definite swing towards science in the upper forms of the grammar and public schools. This trend towards science in the schools is already leading to an increase in the pressure of science entries to the universities, where the balance as between arts and science (including technology) in numbers of students is, in consequence, also moving in the direction of the latter. This movement towards science among the youth of Britain has been slow to begin, since alterations in the numbers following particular vocations rest on changes in social attitude; but once begun, the rate of change is liable to increase in a spectacular manner. The provision of proper facilities for higher education in science and technology, adequate to deal with the increasing number of students coming forward now and in the future, is thus a matter of real urgency.

How these facilities should best be provided has been widely and, at times, hotly debated. On one hand, the new colleges of advanced technology have been created, which will train men and women for the Diploma in Technology, and the so-called 'sandwich courses' in a variety of technological fields are being developed and extended. On the other, in addition to expenditure in these directions, the Government has also provided greatly increased sums towards the extension and maintenance of scientific and technological facilities in the universities and for the furtherance of research, since training at a high level and the pursuit of research go hand in hand. The universities occupy a position of supreme importance in this field, for not only is it in them that most of the fundamental research is carried out on which technological progress ultimately depends, but also the breadth of cultural outlook which they can give is a vital quality in those destined to lead in scientific and technological work or to teach the following generations.

It is against this background that the announcement of the plan to found a new college—Churchill College—at Cambridge must be viewed. The University of Cambridge already has a world-wide reputation for its scientific departments and its engineering school, and it has shown its awareness of the needs of to-day by expanding existing scientific and technological activities and by the creation, in recent years, of strong and growing schools of metallurgy and chemical engineering. As befits a great university, this scientific strength is paralleled by its distinguished tradition and strength in the humanities. The University is essentially residential, and a substantial factor in its success has been its adherence to the college and tutorial systems, under which students at all levels have the broadening influence of mixing freely both with students of other disciplines and with senior members of the University engaged in teaching and research. When it comes to an expansion in numbers, the college system does, however, impose limitations. Already the Cambridge colleges are swollen to a size that is severely taxing their resources in buildings and endowment, and any further expansion of them would threaten the complete breakdown of the system. To permit an expansion in student numbers, and particularly to accommodate increased numbers of men following postgraduate courses, and at the same time to retain the proved merits of the Cambridge system, it is proposed that a new college be founded in Cambridge.

Under the presidency of Sir Winston Churchill, the Trustees of the new College are representative both of the University and of industry: Lord Tedder (chancellor of the University), Lord Adrian (vice-chancellor), Mr. N. G. Annan (provost of King's College), Mr. W. J. Carron, Viscount Chandos, Sir John Cockcroft, Prof. B. W. Downs (Master of Christ's College), Sir Alexander Fleck, Lord Godber, Sir Alexander Todd and Lord Weeks. It is well known that Sir Winston Churchill's support for science during the Second World War was an important factor in turning the scale in favour of Britain and its allies, and he has shown a deep interest in, and concern for, the advancement of scientific and technological education. The Trustees feel that the creation of a new college predominantly devoted to the advancement of science and technology in a University already famous for its scientific achievements would be a supremely fitting tribute to this great man, and Sir Winston has consented that it shall be called Churchill College.

It is proposed that the new College should have a strong bias towards science and technology in its admission policy, although its membership would not be wholly scientific and technological, since the presence of a proportion, reasonably strong but not more than 30 per cent of students of other disciplines, would be desirable on all grounds. Equally, the fellowship would be primarily, but not exclusively, scientific and technological, and the creation of a number of visiting fellowships would enable the introduction of specialists in various fields from abroad to the benefit of the College and the University. A feature of the proposed College will be a ratio of postgraduate to undergraduate members considerably higher than that of existing colleges, and it will seek to promote and encourage postgraduate courses of study for men with some experience in industry and to attract postgraduate students, not only from Britain but also from overseas. It would seek thus to become a centre of attraction for young scientists and technologists throughout the English-speaking world, promoting contact between them and disseminating more widely new knowledge and the technique of its application.

The Trustees believe that creation of Churchill College gives an opportunity to increase the output of men in Great Britain trained at the very highest level; for it takes advantage of the Cambridge system, its tradition, its great prestige in science and the arts and its consequent appeal to talented young people. Moreover, the College fits into the Cambridge educational pattern without in any way distorting it.

In estimating the cost of building and endowing Churchill College, the Trustees have reckoned that provision should be made for 500–600 members with a fellowship of 50–60 as an ultimate size. For this, a sum of approximately £3½ million would be required. This is a bold and imaginative project, the fulfilment of which would surely be in the national interest. Although the sum involved may seem large, the Trustees believe they are justified in appealing for support on this scale, and indeed substantial support has already been received from industry. For the cause, they point out, is a worthy one—to make a real contribution towards the production of leaders in science and technology, and to provide in Churchill College the permanent memorial to one who, more than any other, has earned the gratitude of the English-speaking peoples.

LAKE PHYSIOGRAPHY

A Treatise of Limnology

By Prof. G. Evelyn Hutchinson. Vol. 1: Geography, Physics, and Chemistry. Pp. xiv+1015. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1957.) 156*s*. net.

THE first volume of Prof. Hutchinson's *magnum opus* is now to hand. It deals with the physical half of limnology, or rather of limnology in its narrower sense as the science of lakes. There is nothing about running waters as such, and while this is a minor drawback in the present part, as the physical delimitation between stagnant and running waters is fairly clear, the exclusion of running waters must present the author with considerable difficulties in the forthcoming biological part. One also misses some mention of the biotopes of ponds, swamps, mires, and springs, which are no less important for an understanding of the ecology of lakes.

The restricted use of the word limnology ought certainly to have been indicated by an addition to the sub-title: Geography, Physics, and Chemistry *of Lakes*.

The present volume of more than 1,000 pages is divided into 17 chapters, the titles of which give a fair summary of the contents of the book: 1, The Origin of Lake Basins; 2, The Morphometry and Morphology of Lakes; 3, The Properties of Water; 4, The Hydrological Cycle and the Water Balance of Lakes; 5, The Hydromechanics of Lakes; 6, The Optical Properties of Lakes; 7, The Thermal Properties of Lakes; 8, The Inorganic Ions of Rain, Lakes, and Rivers; 10, Carbon Dioxide and the Hydrogen-Ion Concentration of Lake Waters; 11, Redox Potential and the Iron Cycle; 12, The Phosphorus Cycle in Lakes; 13, The Sulfur Cycle in Lake Waters; 14, The Silica Cycle in Lake Waters; 15, Minor Metallic Elements in Lake Waters; 16, The Nitrogen Cycle in Lake Waters; 17, Organic Matters in Lake Waters.

The geomorphology of lakes is very fully treated; an enormous amount of material has been collected. Sometimes, however, the author seems to be not quite clear as to his intentions—whether to give a catalogue of lakes, or to treat lake types according to their origin and morphology. In the last respect, systematization has been carried too far. The reviewer, as a young man, once made a subdivision of Norwegian lakes into fourteen different types, a feat which has troubled his conscience ever since. Now Prof. Hutchinson enters the absurd by establishing seventy-six different lake types, all numbered and defined, even to "perhaps due to compression waves in the air around a meteorite as it approaches sandy sediments".

The chapters on physics and chemistry are of the highest value, fully documented, and authoritative in treatment. The author encounters the difficulty that must always beset a treatise on limnology. At what stage should biology come in? This is a conspicuous difficulty when dealing with water chemistry, as the organisms and the detritus arising from them so profoundly change the contents of dissolved gases and salts in the waters; but even when dealing with the optics of lakes, or their temperatures and densities, the biological factor is an important one. Here, the author is compelled to presuppose a knowledge of the direct and indirect action of organisms upon the medium, while he intends to treat some physico-chemical factors more fully in the next, biological, volume.

Presentation is the crux in such a pronouncedly synthetical discipline as limnology. All the facts, physical and biological, are so bound together by their interaction that they ought to appear complete and simultaneously as materials for the synthesis. This, of course, is impossible, and the balance struck by the author seems very reasonable. Perhaps, even greater clearness could have been achieved by restricting the present volume to the physics, and more non-biological chemistry of lakes, and treating the water chemistry as influenced by biological processes in the next volume on lake biology.

The point of view in the chapters dealing with the chemistry of lakes is largely a geochemical one, and this very forcibly brings out Prof. Hutchinson's vast store of knowledge, and power of comprehensive treatment. We thus get much more than a mere treatise on freshwater chemistry and chemical processes within the lakes. The role of inland waters in the surficial geochemical cycle appears very clearly, and limnology emerges as an important link among the disciplines that must be brought together fully to describe the geophysics, geochemistry, geomorphology, and ecology of the earth in what the reviewer has proposed to call its *geophysiography*.

Prof. Hutchinson is to be sincerely congratulated upon the appearance of this first volume of his large-scale "Treatise on Limnology". A work combining a somewhat exhaustive treatment of the existing material with a highly personal approach is bound to be of equal value to students of limnology, and to workers on allied subjects. KAARE STRØM

PROGRESS IN CEREAL SCIENCE

Modern Cereal Chemistry

By Dr. D. W. Kent-Jones and Dr. A. J. Amos. Fifth edition. Pp. ix+817. (Liverpool: The Northern Publishing Co., Ltd., 1957.) 105*s*.; 15.25 dollars.

THE five editions of this book cover an interval of thirty-three years. Throughout this time both authors have made many valuable contributions to the subject and it is therefore not surprising that their books, rightly regarded as authoritative and critical reviews of cereal science and technology, are so much appreciated by scientists, technicians and students alike. However, with a decade of intensive research, much of it stimulated by the exigencies of war, the previous edition has gradually become out of date and this new revision now brings us abreast of current knowledge again.

The book contains eighteen chapters, mostly retaining their old titles, together with eight appendixes and a superb bibliography of about 1,100 references. As would be expected, the subject-matter in every chapter has undergone extensive revision. Two new contributors, J. M. C. Parry and R. C. Sims, have completely rewritten the chapter on barley, and E. E. Turtle and J. A. Freeman are responsible for a new and outstanding chapter on "Infestation by Insects and Mites". Perhaps, however, the next edition will also take note of the depredations of the rodent. Among many other additions, a valuable section on faults in bread strengthens the informative chapter on "Technique and Chemistry of the Baking Process". The chapter in previous editions, "Some Physico-Chemical Aspects of Flour", has now been largely incorporated into the chapter on flour strength, a difficult subject handled with great skill.

For such a comprehensive work errors and misprints are commendably small in number. A few, of minor importance, have been noted; for example, an ambiguous statement (p. 60) relating to the amount of Holdfast wheat grown in England. Over the past few years the annual production of this variety has fallen steadily to a relatively small amount. Meanwhile, the acreage of the newer higher-yielding varieties, but of poorer milling and baking quality, like Cappelle Desprez, has increased. Similarly (p. 116), the authors wrongly cite Eagle as having the highest kernel content of British oat varieties, whereas the original reference mentions several superior in this respect. A few misprints also occur in the analytical data of Table 88, particularly in those for the oil content of the reduction flour streams.

The most surprising omission from the authors' choice of material is the pioneer work of Hess leading to the technical development of processes of flour fractionation based on particle size. These processes are capable of separating flour into fractions of widely different protein content and their commercial potentialities are now generally recognized. Appendix 8 with its 23 pages of tables for the amounts of oil, protein, etc., contributed at each of sixteen levels by some forty-three ingredients of animal feedstuffs, could also have been greatly condensed by simply tabulating the basic analytical data required for such computations.

Among the chapters deserving special commendation are those on "General Analytical Procedure for Cereals", a masterpiece of 121 pages, and "Dough Testing Apparatus". The analytical methods described are mostly those personally recommended by the authors. A final chapter, with detailed instructions for the determination of vitamins and the microbiological assay of amino-acids, should prove invaluable, although it might have been strengthened by some mention of the ion-exchange methods introduced by Moore and Stein for the determination of amino-acids.

The high price of this edition, more than double that of its predecessor, is a reminder of a less-pleasant advance in this decade, that of inflation. Nevertheless, the book is excellent value and the authors and publishers are to be congratulated on the production of what is now a classic work in this field.

J. B. HUTCHINSON

WHAT MAGNETO-HYDRODYNAMICS IS ABOUT

Magnetohydrodynamics

A Symposium. Edited by Rolf K. M. Landshoff. Pp. x+115. (Stanford, Calif.: Stanford University Press; London: Oxford University Press, 1957.) 32*s*. net.

UNTIL about ten years ago, magneto-hydrodynamics (or hydromagnetics, as it is more compactly styled) was regarded as the private province of astrophysicists and geophysicists. True, a few experiments had been made on the motion of liquid mercury in a magnetic field, but these were regarded as having little relation to the cosmical phenomena, because of the enormous differences in scale, time of decay, etc. When the possibility of thermonuclear generation of energy began to be considered seriously, however, hydromagnetics had at once to be regarded as a practical laboratory subject. The only known large-scale thermonuclear generators are in the interior of stars; the only known mechanisms for producing the ionization and the particle energies encountered in the stellar generators are electromagnetic. Thus hydromagnetic phenomena were clearly significant for thermonuclear generation; the ZETA project has in fact owed its success to research on the principles of hydromagnetics.

Accordingly, people have recently been asking what this hydromagnetics is about. With the view of answering them, the Lockheed Missile Systems

Division sponsored a symposium on the subject in California in December 1956. The reports presented at the symposium have now been collected into a printed volume, in order to make the information contained in them more generally available.

Because of its aims, the book does not delve deeply into the details and difficulties of the subject, but simply indicates in general terms the problems encountered and the progress so far made towards solving them.

The topics discussed were various. On the theoretical side these included scaling laws (Kantrowitz and Petschek, Landshoff), dynamo theories of cosmical magnetic fields (Elsasser, Hoyle), the penetration of shock waves into a magnetic field (Burgers), the dynamics of a pinched discharge just after onset (Rosenbluth), and hydromagnetic wave guides (Newcomb). The experiments described were chiefly concerned with shock waves, especially those driven by magnetic stresses (Kolb, Kash, Petschek), though shock waves suddenly passing into a magnetic region were also discussed (Kantrowitz). The instability of a liquid sodium film accelerated by a magnetic field was also described (Colgate).

Some obvious criticisms can be made: as is natural in a report of a symposium, there is some overlapping of sections; on the other hand, often (and particularly in the experimental chapters) too much has been omitted for easy comprehension. Again, the standards aimed at are very different; for example, most authors eschew mathematics except as a means of illustrating the argument, but the section by Burgers makes few concessions to human frailty. There are also too many rather obvious misprints.

None the less, a general account of this kind will undoubtedly fill a need. The book gives an interesting and readable account of some of the recent work. As a part of this has not been discussed in earlier reports, the book has a definite value.

T. G. Cowling

RECENT NUCLEAR PHYSICS

Progress in Nuclear Physics

Vol. 6. Edited by Prof. O. R. Frisch. (Progress Series.) Pp. vii+297. (London and New York: Pergamon Press, 1957.) 84*s*. net.

THERE are nine articles in Prof. Frisch's sixth volume: on isotope separation by multistage methods, by T. F. Johns; nuclear models, by R. J. Eden; nuclear moments and spins, by K. F. Smith; spectroscopy of mesonic atoms, by M. B. Stearns; masses of atoms of $A > 40$, by H. E. Duckworth; electromagnetic isotope separation, by M. L. Smith; fission recoil, by G. N. Walton; masses of atoms of $A < 40$, by J. Mattauch and F. Everling; and parity non-conservation in weak interactions, by O. R. Frisch and T. H. R. Skyrme.

Four of the articles are devoted to isotopes. Johns reviews the principles and results of separation by electrolysis, distillation, chemical exchange, diffusion, and thermal diffusion, all of which may be used on a large scale, and refers to other methods used on a laboratory scale. The electromagnetic process, reviewed by M. L. Smith, gives high enrichment in one stage and is much used for gram quantities of a wide range of isotopes. Duckworth tabulates the latest mass values for $A > 40$, discussing the sources and the remaining inconsistencies, and proposes mass standards for the heavier atoms. Mattauch and Everling treat the lighter elements, and review the calculation of binding energies and masses from the observed data; they direct attention to small but systematic discrepancies between mass spectroscopic and nuclear data.

Many different nuclear models have been developed to represent various aspects of nuclear behaviour, and Eden's theoretical survey deals with the main features of models for low-energy nuclear structure, the compound nucleus model for nuclear reactions, the statistical model, the optical model, models for high-energy reactions, and recent work on a many-body theory. K. F. Smith gives a thorough description of the experimental determination of nuclear spins and magnetic and electric moments, together with the theory underlying the methods and the interpretation of the results. Mrs. Stearns shows how spectroscopic studies of mesonic atoms, made possible by the intense beams from synchrocyclotrons, are providing new information about nuclei (for example, on nuclear radii and charge distribution) and reviews the results obtained.

The important and exciting discovery of parity non-conservation in certain weak interaction phenomena occurred after publication of the previous volume. Frisch and Skyrme now review the experimental and theoretical situations, respectively. The results of experiments on asymmetries in beta-decay and π–μ–e decay have been broadly accounted for by the two-component neutrino theory, though there are some discrepancies. Work in this field is still in its infancy, but Prof. Frisch has wisely broken his normal rule (of including only those subjects which have attained a measure of stability) in view of its very great interest and importance.

In the remaining article, Walton reviews the fission process with emphasis on the recoiling fission fragments and their slowing down in the surrounding matter, including chemical properties and effects.

The material is again authoritatively and clearly presented, with plenty of graphs and tables where appropriate, and all the articles carry good lists of references. Publication has been rather late again, but Prof. Frisch promises greater regularity in future, with volumes appearing about September each year.

T. G. Pickavance

PARASITE AND HOST

First Symposium on Host Specificity among Parasites of Vertebrates

Pp. 324. (Neuchatel: Institut de Zoologie, Université de Neuchatel, 1957.) n.p.

THE complex subject of host-specificity among parasites, so important for the understanding and control of organisms living in this manner, has waited too long for the organized investigation which was started, in April 1957, by the conference the proceedings of which are published in this remarkable volume. Originating, as Prof. J. G. Baer, the general secretary of the conference, explains, in a conversation between Miss Theresa Clay and Prof. Ernst Mayr, the conference was financed by the International Union of Biological Sciences and the University of Neuchâtel, and the results have amply justified the expenditure incurred.

It is impossible to indicate, in a short space, the wealth of information, and of stimulating argument, suggestion and speculation, that the volume contains. Nor would it be fair to select for special mention any

of the 21 papers given at the conference ; they are all good ; and they are important reading, not only for the parasitologist, but also for biologists in general. Seven of the papers are in French, one is in German and the others are in English.

Some of the participants in the conference were specialists on the hosts, others were experts on the parasites, and discussions between them threw interesting and valuable light on almost every aspect of the host-specificity of the parasites discussed, which included trematodes, cestodes, nematodes, the ecto-parasitic fleas and lice, and the pupiparous Diptera. Other papers discussed mammalian phylogeny and the evolutionary aspects of the classification of fish, and one outcome of the conference was that the basic working hypothesis on which it proceeded, namely, that there is a tendency towards a parallel phylogeny of parasite and host, was, in a considerable number of cases, confirmed. The value of studies of host specificity for taxonomic work on the hosts was examined and the limitations of this approach to taxonomy were made clear. Nor were the bio-geographical, physiological and biochemical aspects of host-specificity neglected. The conference showed, in fact, how the very considerable knowledge we now have of parasites may contribute materially to discussions of the evolution, zoogeography and general biology of the hosts. The complications introduced by the similar study of intermediate hosts were also well brought out. The whole conference, in fact, emphasized the apparent simplicity, but profound significance, of one of Prof. Baer's prefatory remarks —that host and parasite constitute a biological entity and that the parasite cannot exist without the host.

The volume concludes with a chapter on the collection and preservation of both internal and external parasites which should do much to prevent waste of valuable material due to faulty methods of collection or preservation, or to failure to identify the hosts or to note the localities in which they were found ; it will also correct the impatience of those who expect speedy identification of parasites, the correct naming of which may involve much time and specialist labour. As this chapter says, parasites of all kinds are very much needed and this volume shows how their collection and correct identification may help to throw valuable light, not only on problems of interest to the parasitologist but also on questions that are part of the life-blood of biology in general. One closes the volume with the conviction that this conference marked a notable advance in the study of animal life, and the hope is strong that this first symposium will be followed by others on similar lines.

G. LAPAGE

CELLS, NORMAL AND MALIGNANT

The Life and Death of Cells

By Joseph G. Hoffman. Pp. 288. (London : Hutchinson and Co. (Publishers), Ltd., 1958.) 35*s*. net.

Biological Aspects of Cancer

By Sir Julian Huxley. Pp. 156. (London : George Allen and Unwin, Ltd., 1958.) 16*s*. net.

THESE two books, one by a leading biophysicist and the other by an eminent biologist, deal with some of the more profound aspects of life. Dr. Hoffman examines the properties of living matter and attempts with some success to translate the technical terminology into an understandable presentation for the general reader. In the book, he uses a lively, dynamic style to describe life as a physical process with particular reference to tissue cells, analysing their morphological peculiarities, movements and changes in functions. The information given is diverse and detailed ; we learn about the molecular weight, length and thickness of the myosin component of the contractile mechanism in the muscle, the amount of water which daily goes into the kidney, the number of cells making up the human body and many other startling facts. The chapter on tissue turnover, destruction and repair processes is well written and is of special interest to biologists as the subject is presented from the point of view of the physicist. Growth by cell multiplication is likened to a chain-reaction, the basic property of which is economy of effort. According to the author, the less often a cell has to go through division, the greater is the margin of safety in avoiding mistakes during growth.

Many statements in the book are thought-provoking and there will be readers who would like to know more about the facts and method of analysis on which these statements are based. It is deduced, for example, that each human being has many atoms which came from the fifth preceding generation and would go back in time as far as 200 years, and that only 3,400 divisions have occurred in the germ line since the time of Egyptians (3,500 B.C.). Unfortunately, Hoffman's book is devoid of any reference which could be consulted.

Chapters dealing with biological fibres, macroscopic and microscopic physical forces, the fallibility of living processes, and "the immortal template", deoxyribonucleic acid, require substantial background knowledge from the reader in order to follow the author's arguments, many of which are novel. Dr. Hoffman discusses the importance of death at the cellular level, and convinces the reader that every moment of life for the animal body depends upon the death of cells in the tissues. Cell-death according to schedule is a biological necessity. The cancer cell is the negation of death and the author analyses the behaviour of this abnormal cell in much detail.

The malignant cell constitutes the subject of Sir Julian Huxley's book, part of which has been published previously in two articles in *Biological Reviews*. A great deal of information is presented, based on more than five hundred references and numerous personal communications. One can well believe that the preparation of this review involved Huxley in " . . . more hard labour than anything he has attempted since taking the First Honours examination in Zoology at Oxford !" The book provides a rather condensed yet many-sided view of the subject. We read about the distribution of cancer in vertebrates, invertebrates and plants, viruses which can produce cancer, epigenetics, differentiation and dedifferentiation in relation to cancer. The author describes the process of natural and experimental carcinogenesis, and outlines a method of research which should aim at the prevention of cancer. Malignant disease is viewed as a general biological problem in which the phenomenon of genetic determination plays a central part. The incidence of tumours and tumour-types differs not only in different species but also in different strains, which indicates that the genetic mechanism is implicated in determining cancer proneness. Many examples are quoted in which tumours are associated with chromosome imbalance or with the effect of a single gene. The various mechanisms by which the evolutionary pro-

cesses mutation, variation, selection and adaptation operate in tumour-cell populations are described. The author accepts the view that selection exerts a delaying effect on the incidence of common cancers until after the reproductive period and as a result the peak-incidence of cancer in man is shifted to a later age. This idea, first put forward by E. B. Ford, has important consequences and it could and should be tested experimentally.

Huxley's review represents the biologist's attitude to cancer, according to which cancer is "not a disease at all but an assembly of many different diseases having a certain symptom in common", the elucidation of which is bound up with advances in a number of key fields of present-day biology. He believes that in the future organization of cancer research the various disciplines of general biology and medicine must work together if true progress is to be achieved. Huxley's book is a testimony of this belief as well as a rich source of information and ideas, which should benefit biologists as well as clinicians. Reading the book, one often comes across problems, which are illuminated by Huxley's analysis from an entirely new angle; for such moments his labours are well rewarded.

P. C. Koller

THE INDIAN MANGO DISPLAYED

The Mango

By S. R. Gangolly, Ranjit Singh, S. L. Katyal and Daljit Singh. Pp. xiii+530 (278 plates). (New Delhi: Indian Council of Agricultural Research, 1957.) 85*s*.; 12 dollars.

THE mango, "the choicest fruit of Hindostan", has escaped much of the scientific study to which other popular fruits have been subjected. It has been cultivated in India from earliest times, and seedling propagation during many centuries has produced innumerable varieties showing, as an authority has remarked, a gradual continuous change in their characters, intergrading in range. Within the past 400 years, vegetative propagation has been used to perpetuate desirable trees, and cultivars recognized by appearance and name have been increasingly grown.

The object of this book, compiled by four pomologists under the auspices of the Indian Council of Agricultural Research, is to describe the most important of these cultivars and to register in permanent form their names and special features. After short introductory chapters on the place of the mango in India and on its botany, an account is given of the characters reckoned of importance in distinguishing cultivars, and there follows, in the main part of the book, a survey of 210 of them, each portrayed by a life-size coloured illustration on one page and a verbal description on the next. A short concluding section discusses the cultivation of the tree, and the pests and diseases which attack it, and some quantitative characters of the cultivars are given in an appendix. The illustrations are attractive, the descriptions have every appearance of care and precision, and from their study the reader can readily see the wide range of characters exhibited by Indian mangoes. The book is nicely printed and attired and has a good bibliography and index. In what they have attempted, the authors and publishers could scarcely have done better.

It is, perhaps, being ungrateful to wish they had attempted just a little more. Nearly fifty years ago, Burns and Prayag, writing of the multiplicity of forms of mango, added: "Without some classification we have chaos. According to what scheme can this chaos be reduced to order?" They tried a scheme themselves, grouping the mangoes on fruit characters, the round-fruited, the long-fruited, those with beaks, those with ridged shoulders—a rough-and-ready arrangement, perhaps, but at least some attempt at grouping. Later workers in India and elsewhere (including one author of this book) have added to it, and the reader might be excused if he opened this new book hoping to find a further step taken in arranging the hordes of mangoes into some sort of ordered scheme. In this he would be disappointed. The cultivars follow each other according to the alphabetical order of their common name and, although distinguishing characters are mentioned for each, no attempt to group them is made. The reader wishing to name a fruit is unprovided with a key to help him, and must thumb his way through more than 400 pages to find the picture and description which best correspond.

It may be that mango cultivars are even less apt than those of the apple to fall into convenient classes, and the authors perhaps thought any grouping too unsatisfactory to adopt. Or they may have it still in mind, and this study may be a preliminary stage to a well-found system of classification. In any event, we are indebted to authors and artist for having gone so far in making accessible a new store of information about the mangoes grown in various parts of India, and in clearing away some of the confusion which surrounded their identity.

T. A. Russell

THEORIES OF EVOLUTION

The Origins of Life

By Albert Ducrocq. Translated by Alec Brown. Pp. xvi+213+4 plates. (London: Elek Books, Ltd., 1957.) 25*s*. net.

The Evolution of Living Things

By Prof. H. Graham Cannon. Pp. x+180. (Manchester: Manchester University Press, 1958.) 12*s*. 6*d*. net.

AMONG the many fascinating speculations which confront students of evolution are two which enjoy considerable priority. How does the infinitesimally small gene particle exert its all-powerful influence on hereditary developments? Can individual characteristics be transmitted by some form of cytoplasmic inheritance? Despite much investigation and many thoughtful hypotheses the answers to the questions are far from satisfactory. It is a pleasure, therefore, to recommend two books where views on these matters are so vigorously propounded that, even if unacceptable, they are bound to attract attention.

Albert Ducrocq is a French electronic engineer who uses his experience of cybernetics to investigate the origins and development of living matter. As a background to the biological discussion Ducrocq describes the nature of the mechanisms involved in the control mechanisms used in automatic factories and compares them with the complex system of homœostatic controls used by the living creature. After dealing with contemporary biochemical research into the origin of life, he then indicates how investigations into the use and applications of computing

machines could throw light on the reproductive mechanisms of living creatures. Finally, the author sketches man's place in the universe and shows that it is his capacity for abstract thought, language and tool-making which enables him to transcend organic evolution.

The value of the book lies in the way Ducrocq uses cybernetics to bridge the gap between physical and biological systems. Physicists are already suggesting that it may not be impossible to give a machine an instruction to make another like itself and to provide this with a copy of these instructions : such a machine would have some claim to being alive. Biologists working on the structure of deoxyribonucleic acid are suggesting that this chromosomal substance can not only duplicate itself but also controls the development of the cell in a specific way. Physical systems usually show a tendency to run down or increase their entropy. Biological systems take in raw material from their environment and, by using it to repair and reproduce themselves, tend to organize themselves on to a higher level. Through the use of relay systems, of servo-mechanisms, the engineer is now able to construct machines which, like living organisms, are able to control their internal organization. From this Ducrocq introduces the concept of the gene as a servo-mechanistic device, a concept which will undoubtedly lead to fresh thinking and new investigations. But whether the use of the term 'servo-mechanism' for such substances as genes, vitamins, hormones and enzymes really throws new light on the way in which gene particles influence hereditary development is open to question, as is much of Ducrocq's ensuing philosophical discussion.

"The Origins of Life" has already gained considerable prominence in France, and, in this admirable translation by Alec Brown, deserves serious consideration by English-reading peoples. As the book is likely to become a prescribed book for students, any future edition should be provided with an index.

Prof. H. Graham Cannon's book is much more clearly written than Ducrocq's. It is intended for the layman and is couched in language designed to stimulate both thought and emotion. The theme is simple enough. Lamarck, writes Cannon, has been steadily misinterpreted and denigrated since his death in 1829. For many years Lamarckism has been synonymous with the inheritance of acquired characters. This was but one of four laws enunciated by Lamarck and is not only superfluous to his main hypothesis but also, by its repeated declaration, deprives Lamarck of the credit for his great contribution to evolutionary thought. This is found in his fourth law and states that "the production of a new organ in an animal body results from a new need which continues to make itself felt, and from a new movement that this need brings about and maintains".

Many biologists will question whether Lamarck has been so grossly misrepresented and will ask for more information about Cannon's dogmatic assertion that change in the soma must be reflected in the gonads "as a purposeful force ensuring that the good developed during one generation shall be passed on to the next".

One of Cannon's main arguments for supporting Aristotle, Bergson, Driesch and others who believe that there is a guiding force within the organism stems from the fact that Mendelian inheritance can go back only as far as the origin of chromosomes and that "there is no right to assume that it went back any further". In primitive organisms like viruses and bacteria, inheritance must have been entirely through the protoplasm, and, if cytoplasmic inheritance is the mechanism of inheritance in lower organisms, it cannot be ruled out in the higher. In the rest of his book, Cannon develops this theme and argues that the claims of those who subscribe to the theories propounded by Darwin and Mendel have been considerably over-rated.

Although this book has been somewhat testily written, it is one which should be taken seriously, and not only by laymen. Although Cannon may not command much support for his re-incarnated vitalistic theory of evolution, the difficulties he finds in accepting a theory of evolution by natural selection in which small variations are inherited according to Mendelian laws will find echoes in many quarters. The inheritance of characters through cytoplasm needs much more investigation. This is a book for those who are anxious to understand how life evolves.

T. H. HAWKINS

MATHEMATICIAN EXTRAORDINARY

Niels Henrik Abel

Mathematician Extraordinary. By Prof. Oystein Ore. Pp. viii+277+16 plates. (Minneapolis, Minn. : University of Minnesota Press ; London : Oxford University Press, 1957.) 45*s*. net.

THE name of Abel is well known to anyone who has studied mathematics to university-level. Those who miss Abelian varieties, or even Abelian groups, at least know his convergence test, and are often aware that he published the first satisfactory proof that the general quintic cannot be solved by radicals. He was a very nineteenth-century genius. The son of a drunken Norwegian clergyman and his profligate wife, he faced poverty as a student ; his subsequent rise to fame was hampered by the indifference, and sometimes the misunderstanding, of the established great ; his hope of financial reward was frustrated by official vulnerability to pressure groups ; and he died of consumption at the age of twenty-six. It is an interesting story, and on the whole this book tells it very readably, in spite of a rather hagiographic attitude to the main character, and an excessive pursuit of detail concerning subsidiary ones.

The dust cover claims that the book "is also a case history of our perennial problem of how to detect genius and ease its path". But to my mind the prevailing impression is rather of the contrasts between the academic worlds of the nineteenth century and of to-day, contrasts of structure, attitude and atmosphere, which, of course, parallel and reflect corresponding contrasts in almost every human sphere. The young genius of to-day will find difficulty not in getting his work published, but in getting it noticed amid the flood from his ordinary sound contemporaries. If he dies at twenty-six, it will not be of consumption, but in a mountaineering accident ; and however real his genius, so dying, he will surely not leave so deep or so lasting a mark on so wide a sector of his subject as did Abel. That these contrasts are not explicit in the book is perhaps less a fault than an indication of the author's intentions. That they present themselves so sharply upon reading it is a measure of the vividness of the picture he draws.

GRAHAM HIGMAN

White Dwarfs

By Prof. E. Schatzman. (Series in Astrophysics.) Pp. viii+180. (Amsterdam: North-Holland Publishing Company, 1958.) 19 guilders.

THERE has been much progress recently in our knowledge of white dwarf stars and Prof. E. Schatzman has been intimately concerned with this work. White dwarfs are of great interest to both physicists and astronomers; to the former because of the stimulus given to the study of dense degenerate matter and to the latter because this special type of star may account for a few per cent of the stars of the galaxy. The study of white dwarf stars requires knowledge of many branches of theoretical physics, and Schatzman introduces these as they are needed. After two chapters on the discovery and observational characteristics of the stars, he discusses peculiarities in their spectra and how they can be interpreted. In an account of the properties of dense matter and the structure of white dwarf stars, he shows how modern developments of quantum mechanics have modified Chandrasekhar's earlier theory. The problem of energy generation in white dwarf stars necessitates a discussion of nuclear reactions at high densities.

It is not sufficient that equilibrium configurations of stars exist; they must also be stable, and Prof. Schatzman discusses many aspects of their stability. In considering convectional stability he uses a somewhat restrictive criterion which does not allow mixing between rising and falling convectional currents. Because of this, models of white dwarf stars with many alternating convective and radiative zones may be unnecessarily complicated. The final chapter concerns the origin and evolution of these stars and is naturally speculative. He suggests that not all of them can be remnants of massive stars, and that some must be formed directly as white dwarfs. This is an open question. Prof. Schatzman has given us a worthwhile book on a subject of great interest, and anyone wishing to study white dwarfs will be grateful to him. The book is very well produced.

R. J. Tayler

Treatise on Inorganic Chemistry

By Prof. H. Remy. Vol. 2: Sub-Groups of the Periodic Table and General Topics. Translated by Prof. J. S. Anderson. Edited by Prof. J. Kleinberg. Pp. xxviii+800. (Amsterdam: Elsevier Publishing Company; London: Cleaver-Hume Press, Ltd., 1956.) 105*s*.

THE second volume of this detailed treatise deals with the transitional elements in the wider sense. It includes discussions of such topics as the metal carbonyls, the lanthanides, the transuranic elements, radioactivity and isotopy, the distribution of the elements and geochemistry, and the reactions of solid substances. There are also sections on the metallic state and intermetallic phases. In each case something is said of the analytical chemistry of individual elements. The important minerals of the various metals and the methods of extraction from the ores are included. The sections on radioactivity and the transuranic elements are very good, although knowledge of the latter has been extended since the book was published. The chapters on colloid and surface chemistry and on catalysis and reaction kinetics, although not as full as in treatments in books on physical chemistry, are quite detailed enough to make the subjects intelligible and provide concise summaries which will be useful to students. There are many tables of data and the physical properties of elements and compounds receive adequate treatment. Not only is the book an excellent text-book, but it will also be found most useful for reference purposes, since it contains in a single volume much information which could otherwise be found only in monographs or large works in many volumes. With so much detail it is inevitable that one or two errors were noticed, for example, the inclusion (p. 372) of nitrocopper as a definite compound, whereas this was shown many years ago to consist of nitrogen dioxide adsorbed on cuprous oxide.

J. R. Partington

Flora of the British Isles

By A. R. Clapham, T. G. Tutin and E. F. Warburg. Illustrations, Part 1: Pteridophyta–Papilionaceae. Drawings by Sybil J. Roles. Pp. vi+144. (Cambridge: At the University Press, 1957.) 25*s*. net.

THIS is a disappointing book and scarcely befitting the authoritative parent flora of which it is a companion volume. With the very high standard set by recent productions, particularly those so beautifully delineated by Miss Ross Craig, any new illustrations of British plants have to be judged by those available. The new volume suffers badly in this exacting test and it is no excuse to claim that the plates are meant to convey the general appearance of the living plant. Some of the drawings and details are very sketchy and the scale adopted throughout the book is much too small for distinctive reproduction of the species. Furthermore, no explanatory notes are given with the plates, merely the botanical names, the common name where one is available, and the colour of the flower. It would have been an advantage to indicate the various organs and the aspect of some of the flower drawings; in several plates it is puzzling to interpret these details.

Flora of Peru

By J. Francis MacBride. (Botanical Series, Vol. 13, Part 3A, No. 2.) Pp. ii+291–744+ii. (Chicago, Ill.: Field Museum of Natural History, 1956.) 5.50 dollars.

IN this volume the author, who is curator of Peruvian botany at the Chicago Natural History Museum, continues the "Flora of Peru" which he began to publish in 1936. This part includes treatments of the families of Malvales and of the Sapindaceae and Theaceae. Peru is rich in Malvaceae, both on the *lomas* of the coast and, above all, on the high *páramos* of the Andes, where the dwarf cæspitose or pulvinate species of the genus *Nototriche*, beloved of the late Sir Arthur Hill, abound in perplexing variety. Mr. J. F. MacBride recognizes more than sixty species of this genus within the limits of Peru, and has accomplished a feat in providing a key to them which, he admits, is "only suggestive". Economic botanists will be interested in the account of the seven native species of cacao, *Theobroma*, which is contributed by Dr. José Cuatrecasas. That large genus of climbing shrubs, *Paullinia*, in Sapindaceae, is of importance to chemists: some of the species occurring in the region of the upper Amazon are well known as providing the *guaraná* of commerce, for containing enough caffeine to be used for a native breakfast drink, as fish-stupefiers and, in at least one instance, as components of some kinds of *curare* poison.

N. Y. Sandwith

PROVISION OF COBALT TO RUMINANTS BY MEANS OF HEAVY PELLETS

By D. W. DEWEY, H. J. LEE and Dr. HEDLEY R. MARSTON, F.R.S.

Commonwealth Scientific and Industrial Research Organization Division of Biochemistry and General Nutrition, University of Adelaide

EXTENSIVE areas of cobalt-deficient grazing lands are now known to be distributed throughout the world[1], and so provision of the modicum of cobalt, necessary to fulfil the nutritional requirements of flocks and herds depastured on these tracts, has become an important husbandry procedure. Several methods, ranging from dosing at short intervals to spreading cobalt dressings on the pastures, have been adopted for this purpose; all in current use, however, are expensive of time and labour, and, with the exception of dosing—which entails frequent mustering—few, if any, completely meet the requirements.

This article describes the development of an improved procedure which involves a new principle.

Basis for Provision of Cobalt

The results of our earliest studies[2], which indicated that cobalt is an essential nutrient element for ruminants, stressed the necessity for its frequent administration. Later, the demonstration[3,4] that cobalt is beneficial only if administered *per os* directed attention to the rumen contents as the primary site of activity, and when more recent experiments[5,6] proved the malady that supervenes on a prolonged shortage of cobalt to be, in fact, the consequence of deficiency of vitamin B_{12}, the origin of the disabilities was associated with particular components of the flora of the rumen. These cobalt-requiring micro-organisms play no part in the fermentative reactions within the rumen contents (Marston, H. R., and Allen, S. H., unpublished work). Their main symbiotic contribution is the vitamin B_{12} they produce, though in certain circumstances, when grazing conditions predispose the animals to phalaris staggers, their particular metabolic propensities become singularly important to the animal.

The high-yielding perennial pasture grass *Phalaris tuberosa*, in association with subterranean clover, has been widely utilized for pasture improvement in southern Australia, and especially for the establishment of productive pastures on the extensive tracts of deficient terrain recently brought into prolific bearing by correction of limitations imposed by deficiencies of zinc and copper within the soils[7,8].

Sheep and cattle confined to phalaris-dominant pastures are subject to the hazard of a nervous malady, phalaris staggers, which frequently is fatal and which in some seasons and in certain areas can lead to the loss of all stock grazed on the new growth of this plant. A chance discovery[9] that frequent administration of cobalt completely protects sheep from this demyelinating disease made way for experiments[10] that showed that the malady occurs only when the cobalt content of the fodder is below a certain limiting value, and protection results only when cobalt is administered *per os*. As parenteral injection either of cobalt or of sufficient vitamin B_{12} to fulfil all physiological requirements of the animals has no influence on the incidence of the malady[11], it is probable that the cobalt-requiring micro-flora destroy the neurotoxic principle of phalaris while it is in the rumen.

Essentially, then, the husbandry problem is to sustain the concentration of cobalt necessary for the proliferation of these micro-organisms. We know something of the quantities involved. When provided with ample cobalt, a mature sheep, on the rations mentioned in the legend of Fig. 2, for example, produces 600–1,000 μgm. vitamin B_{12}/day. Limitation is imposed on production when the cobalt concentration in the rumen contents falls below 20 mμgm. cobalt/gm., at which stage the ultracentrifugate contains about 0·2 mμgm. cobalt/gm., for at these levels most of the cobalt is accumulated by the bacteria. Reduction of the available cobalt to one-tenth of these concentrations elicits marked changes in the micro-flora, and the production of vitamin B_{12} falls to 30–50 μgm./day. These latter amounts are not enough to make good the animal's metabolic losses. Thus, depletion ensues and deficiency symptoms appear in due course (Marston, H. R., and Smith, R. M., unpublished work).

The investigations briefly described below arose from a proposal made by Prof. Perry Stout, director of the Kearney Foundation of Soil Science, University of California, who worked with us throughout the tenure of a Fulbright Fellowship (1955–56). Stout suggested that a vessel containing a concentrated solution of cobalt salt and fitted with an asbestos wick along which cobalt ions would migrate and exchange with other ions within the rumen contents might obviate the frequent drenching necessary to control phalaris staggers, if a means could be contrived to anchor it in the rumen. The device suggested was not feasible. We have, however, devised a practical mode of treatment by turning to account the tendency of heavy foreign bodies to remain within the ruminant forestomachs.

Development of Heavy Pellets to provide Cobalt to Rumen Contents

The two factors that most significantly influence the rate of solution of the various cobalt compounds studied in these investigations are, with little doubt, the *p*H and the redox potential of the rumen contents. To ensure that the requirements of the desired rumen flora are met, a cobalt-containing pellet should, under conditions similar to those defined in Fig. 1, sustain the passage of more than 0·1 mgm. cobalt/day into solution in a form readily assimilable by bacteria.

Preliminary studies revealed that cylinders ($\frac{1}{2}$ in. diameter × 1 in.) of metallic cobalt gave up, by corrosion, the required amount of cobalt when immersed in distilled water in equilibrium with air,

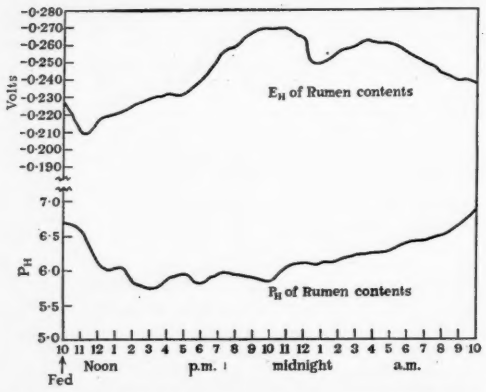

Fig. 1. E_H and pH changes redrawn from continuous tracings of potentials set up between appropriate electrode systems introduced into the rumen contents via a fistula which was then closed securely from the external atmosphere. The polarity of E_H(V.) is expressed according to the convention established by Mansfield Clark. The experimental animal was confined to a metabolism cage and consumed 1 kgm./day of the ration referred to in the legend of Fig. 2, plus a supplement of 1 mgm. cobalt/day

but little, if any, when introduced into the rumen. After desultory experiments with various sparingly soluble cobalt complexes, a study was made of the rates of solution of the cobaltic oxides under conditions prescribed by the milieu within the rumen, and, as a result, pellets which would meet the requirements were developed. These were fabricated by compressing and baking (800–1,000° C.) various mixtures of cobaltic oxide and china clay. The rate at which these pellets give up cobalt under *in vitro* test conditions may be controlled to some extent by varying the heat treatment.

The pellets first selected for extensive trials each consisted of 5 gm. of a mixture of 75 per cent cobaltic oxide (B.D.H.) and 25 per cent china clay (from a deposit at Modbury, South Australia) moulded by compression (about 5 tons/sq. in.) into a cylinder ($\frac{1}{2}$ in. diameter × about $\frac{1}{2}$ in.) with domed ends, and afterwards heated to 1,000° C. for 10 min. When immersed in water, these pellets absorbed 6 per cent of their weight, and in that state had a specific gravity of 3·5. Later, the proportion of cobaltic oxide was increased to 90 per cent, which raised the specific gravity to slightly above 4·1 without materially changing the other properties. The efficacy of these latter pellets is now being examined experimentally under a variety of grazing conditions. Their employment by the pastoral industry has been recommended tentatively while heavier and denser pellets are being developed.

Heavy Cobaltic Oxide Pellets and the Cobalt Requirements of Sheep

Extensive experimental tests leave no doubt of the capacity of cobaltic oxide pellets to meet the requirements of sheep. The results of intensive studies of their effects on sheep confined in pens and fed on cobalt-deficient rations are exemplified by the performance of ewe 006/*W* (Fig. 2); and the results of experimental trials with flocks on cobalt-deficient pastures, of which the responses reported in Fig. 3 are typical, indicate a long-term effectiveness at least equal to that of drenching thrice weekly with the equivalent of 1 mgm. cobalt/day. Estimations of

Table 1. Capacity of Cobaltic Oxide Pellets to prevent Phalaris Staggers in Sheep

Station	Phalaris staggers (per cent)		Weeks after administration
	Untreated* controls	Treated with 75 per cent cobalt oxide pellets	
Glenroy	33	0*	8
Bool Lagoon	60	1·3†	8
Maaope	35	1·7‡	12

* For economic reasons the untreated controls were removed from the phalaris pastures soon after the outbreak of staggers appeared. All would have succumbed if left there.

† A pellet recovered from one animal of this group that afterwards developed the malady was coated with a concretionary deposit of calcium phosphate.

‡ Autopsy revealed that the pellets had been rejected by those that developed the malady.

vitamin B_{12} in the blood plasma and in liver samples, collected by biopsy, thirty and fifty weeks after administration to sheep on cobalt-deficient fodder have confirmed the prolonged capacity of the pellets to provide the cobalt requirements.

During March 1957 pellets were administered to about 1,800 sheep which, together with untreated controls, were depastured as experimental flocks on eighteen sites where *Phalaris tuberosa* had been established on a wide variety of soil-types in south-eastern South Australia. The unusually dry autumn was not conducive to rapid growth of phalaris, and so outbreaks of phalaris staggers occurred only on three stations more favoured by rainfall. There was practically complete protection of treated animals under conditions which precipitated a high incidence of phalaris staggers in the untreated members of the experimental flocks (Table 1). Autopsy of the very few of the treated animals that developed the malady revealed that all but one had shed their pellets. The

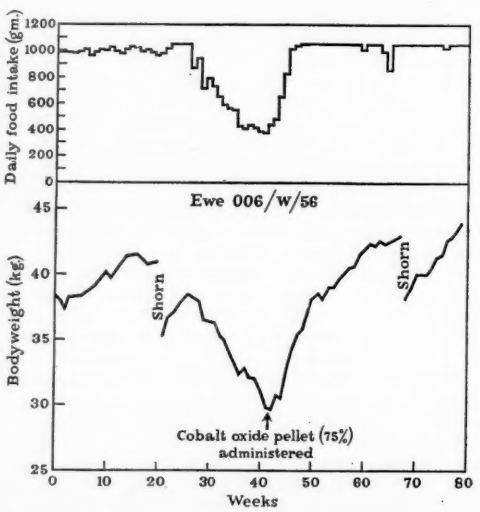

Fig. 2. Effect on appetite, body weight, etc., following administration of a cobalt oxide pellet is typical of the response that supervenes when the very low vitamin B_{12}-status of a cobalt-deficient sheep is reinstated to normal, either by frequent administration of an appropriate amount of vitamin B_{12} *per os* or parenterally, or by the administration of sufficient cobalt *per os* to ensure that the nature of the micro-flora in the rumen contents is no longer influenced by a shortage of cobalt. The experimental ewe was confined to a pen and offered each day a ration comprised of 1 kgm. of cobalt-deficient cereal hay plus 50 gm. of washed gluten. This mixture contained less than 0·03 μgm. cobalt/gm. dry weight

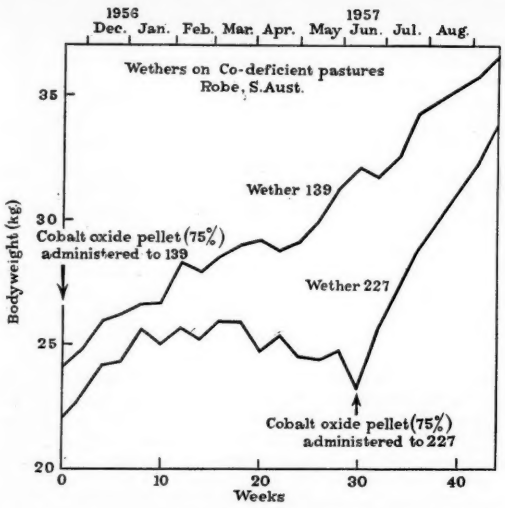

Fig. 3. Administration of pellets to animals on cobalt-deficient pastures at Robe, South Australia, elicited responses similar to those which supervene on frequent (three times weekly) drenching with an adequate supplement of cobalt

pellet recovered from the animal that succumbed was coated with a white crystalline concretionary deposit, about 1 mm. thick, of calcium phosphate which completely masked the cobaltic oxide.

Deposition of Calcium Phosphate on Pellets of Certain Composition

Conditions which dispose pellets to become encrusted with calcium phosphate while in the rumen seem rarely to occur in natural grazing. So far, we have observed concretions on only five pellets among some hundreds recovered after remaining for periods ranging from one to twelve months in sheep grazed under a variety of conditions. Two of these were from mature sheep grazed on lush, phalaris-dominant pastures (winter–spring) in the south-east of South Australia and three were from lambs grazed on mixed pastures (spring–summer) at the Division's Field Station, Glenthorne, near Adelaide. All five contained 20–25 per cent of a particular clay (Modbury). The presence, within the clay matrix, of minerals isomorphous with the crystalline calcium phosphates, or of slightly soluble calcium-containing minerals that would generate nuclei of potentially high calcium ion concentration, would favour accretion of brushite and of apatite from rumen contents, which often become supersaturated in respect to the solubility product of calcium and phosphate ions, especially during fasting when the liquid portion has a *p*H greater than 7·0 and is relatively highly charged with phosphate ions from the saliva. Other factors, such as the ingestion of milk or of calcium-rich fodder plants, might be expected to increase the risk.

The apparent rarity of the phenomenon is indeed remarkable. In certain circumstances, it is a potential hazard, however, which could detract seriously from the prolonged effectiveness of the pellets, and so we are seeking further knowledge of the factors that predispose to it.

Attempts to produce accretions on pellets of various compositions administered to sheep pen-fed on rations containing generous additions of calcium hydrogen phosphate, calcium carbonate, milk, etc., have failed. An experiment, the first of a series, in which pellets of three different compositions were administered to the individuals of a flock of 240 wethers, grazed on mixed (dry) summer pastures, revealed no sign of accretion whatsoever when the pellets were recovered at slaughter 100 days later. Those of a batch containing 25 per cent china clay, referred to above as being particularly subject, were, like the others, entirely free from deposit. In this trial the behaviour of a batch made from a mixture of equal parts of cobaltic oxide and powdered iron, and the relative behaviour of three types of pellets produced commercially from 90 per cent cobaltic oxide and 10 per cent clay, were also examined. *Inter alia*, the freshly eroded surfaces of all pellets from two of these latter batches, which were soft enough for them to become lightly abraded by the rumen contents, contrasted very favourably with the surfaces of the harder pellets of the third batch, which still retained sufficient of the original polish imparted by the die to suggest that the expected rate of solution may not have been attained. Renewal of the surface by mild attrition within the rumen should facilitate solution of cobalt and mitigate the hazard of the accretion of calcium phosphate. As yet we have not encountered conditions which would allow the latter aspect to be examined critically by direct experiment.

Anatomical and Physiological Factors that influence Retention of Heavy Pellets within the Rumen

Internal folds projected by the anterior, the right and left longitudinal, the posterior, and the coronary pillars of muscle tissue within the walls of the rumen separate its interior into a number of diverticula through which the fermenting ingesta are circulated (Fig. 4).

The recurrent muscular movements that determine the excursions of the ingesta within the paunch are, in their simplest forms, the complete reticular–rumen contraction cycle initiated at intervals of 60–180 sec. by the two-stage contractions of the reticulum, and the waves of contractions, usually either two or four, which proceed alternately over the dorsal and ventral sacs of the rumen during the interlude of reticular quiescence.

In the course of the reticular–rumen contraction cycle, the more buoyant material of the rumen contents is flushed posteriorly by the fluid mass ejected from the contracting reticulum; thus it circulates above the denser particles, which gravitate to the rumen floor and are gradually impelled forward by the return flow until they tip over the rumino–reticular fold and are aspirated into the relaxing reticulum. Thus, heavy foreign bodies, such as small metal objects ingested in the fodder, become transported more or less rapidly to the reticulum where, if dense enough, they remain.

The tendency for metallic foreign bodies to lodge in the reticulum after chance ingestion has been known for many years. Schalk and Amadon[12], in their classic study of the dynamics of the bovine forestomachs, observed that iron nails, etc., introduced into the fodder and afterwards swallowed, rarely passed farther back than the anterior pillar of the rumen, and, although a few reached the ventral sac, all eventually found their way to the reticulum and remained there.

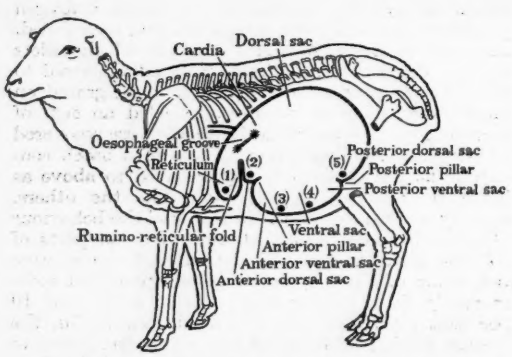

Fig. 4. A heavy pellet, immediately after it is swallowed, usually lodges in the anterior dorsal sac of the rumen (2), from which it soon becomes transferred to the reticulum (1), where it remains. Occasionally, though rarely, the pellet may be found in one of the more posterior positions (3), (4) or (5). If the animal is held supine for some minutes, the pellet is invariably expelled from the reticulum and, when the normal upright posture is resumed, gravitates to the floor of the rumen, usually to lodge temporarily in position (5) or, less often, more anteriorly. It again becomes conveyed gradually to the reticulum

Our experimental observations of the excursions of heavy pellets within the compartments of the smaller, ovine, forestomachs confirm these findings. Several thousand fluoroscopic examinations of individuals in experimental flocks, made feasible under field conditions by a portable X-ray plant designed by our colleague, V. A. Stephen, have provided a wealth of data from which firm conclusions may be drawn.

The initial course taken by the pellet is probably influenced by several variables: the animal's posture and the stage of the rhythm of its rumen contractions when the pellet is delivered into its œsophagus, and the nature and consistency of the rumen contents are all likely to be important in this respect. On reaching the rumen (see Fig. 4), pellets administered by an œsophageal tube usually gravitate immediately to the floor of the anterior dorsal sac (2), whence they become translocated, more or less rapidly, to the reticulum (1). Some may stay for a minute or so high up in the region of the cardia, either suspended in the buoyant foamy scum that accumulates there, or possibly caught in the œsophageal groove, and a small proportion of them go initially to the more posterior positions (3), (4) or (5). Fluoroscopic location of pellets less than two minutes after they were administered to a group of sheep treated and examined in the field revealed 15 per cent in (1), 84 per cent in (2), and 1 per cent in (3). A subsequent X-ray examination about three months later revealed 406 pellets (97 per cent) in position (1), one pellet in (2), six in (3), three in (4), and one in (5). The general pattern of these findings is typical of other experimental trials.

Pellets dislodged by chance from the forestomachs are not retained elsewhere in the animal. Careful X-ray examination of the abdominal viscera of sheep that had lost pellets from the rumen and reticulum has on no occasion revealed to us any evidence of displacement to the omasum, abomasum, or to lower levels of the intestinal tract, and as we have observed when dosing the animals that the rare incidental return of a pellet to the mouth that follows its ineffectual delivery into the œsophagus induces the sheep to champ and immediately reject it, we conclude that pellets are lost via this route. Even a very dense pellet may be observed by X-rays to pitch upwards at each contraction of the reticulum, and so conditions which would favour its entrainment in the fraction of the contents that, during rumination, is regurgitated from the region of the cardia are not difficult to envisage.

Among the several properties of the pellet itself—its size, shape, density, etc., and to some extent the nature of its surface—which might be expected to influence its retention, density is of paramount importance, though overall size is undoubtedly significant.

Some of the heavy objects selected for experiments in the beginning of these studies were made from 1½-in. lengths of ½-in. diameter metal tubing filled with ion-exchange resins, etc.; others were solid cylinders of cobalt and alloys of cobalt; all were heavy (more than 30 gm.) and all remain in the animals after more than two years.

Early in the first series of field trials (*vide supra*) we observed a tendency for the 75 per cent cobaltic oxide pellets to be rejected, especially by individuals of the flocks confined to the long-fibred fodder available from phalaris-dominant pastures. These pellets weighed 5 gm. and had a specific gravity (wet) of 3·5. Between 10 and 40 per cent of them were lost in nine months (March–November 1957) according to the age of the animals and the grazing conditions.

The influence of size and density on retention is being studied experimentally. Pellets of two sizes and three densities were administered to five groups, each of 80 ewes, run together as a flock. Early findings reported in Table 2 emphasize the prime importance of density and indicate the influence of changing pasture conditions.

We consider that the 90 per cent cobaltic oxide pellets, of specific gravity 4·1, recommended by us now for general use are close to the safe limit, and we are developing denser pellets, specific gravity greater than 4·5, comprised of cobaltic oxide and finely powdered iron, which may more nearly approximate the ideal pellet that would remain to fulfil the requirements of the rumen micro-flora throughout the natural life of the animal.

Smooth, heavy objects that lodge in the rumen are well tolerated: we have observed no untoward effects in individual sheep that have carried nine pellets for a period of about a year. Thus, heavy containers contrived to deliver continuously to the rumen contents small quantities of anti-foam reagents,

Table 2. Effect of Size and Specific Gravity on Retention of Pellets in the Forestomachs of Sheep

Pellet specification				Per cent rejected during			
Composed of	Size*	Specific gravity	Weight (gm.)	1st month† Nov. 1957	2nd month Dec. 1957	3rd month Jan. 1958	4th month Feb. 1958
Aluminium	*A*	2·7	4·2	7	7	0	1·25
Aluminium	*B*	2·7	1·5	23	18	13	10
Steel	*A*	7·7	11	0	0	0	1·25
Steel	*B*	7·7	4·5	1·25	0	0	1·25
90 per cent cobaltic oxide 10 per cent clay	*A*	4·0	5·0	0	0	0	0

* Size *A* = ½ in. diam. × ½ in. overall between domed ends; size *B* = ½ in. diam. × ½ in. overall between domed ends.

† After each screening, missing pellets were replaced by others of the same kind.

anthelmintics, etc., might also find application in animal industry.

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SCIENCE IN SCHOOLS

THE British Association Conference on "Science in Schools" was held on April 17 and 18, in the hall of the Royal Geographical Society in London, which was not big enough to hold all the administrators, teachers and lecturers who wished to attend. The purpose of the Conference was to discuss the place of science in the curriculum of British schools to-day in the light of the continued demand for more scientists and technologists, and to assess to what extent the supply of teachers and laboratory accommodation were adequate to meet the demands now being made on the schools.

Sir Solly Zuckerman opened the Conference by explaining why the nation needs more scientists and technologists. There is a relation between the volume of industrial production and the number of scientists working in research, development and production: the Government has decided to plan for a 4 per cent annual increase in industrial production and it has been estimated that this will entail an increase in the annual output of science graduates from 10,000 in 1955 to 20,000 in 1970. This increase should be chiefly among engineers and it is felt that the present 'credit squeeze' and contraction of the defence programme will have no long-term effect on the number of scientists required by industry. The universities and the technical colleges will have to make roughly equal contributions to this increase in the annual output of science graduates. It is estimated that the universities can increase their intake by the required amount by 1970 without lowering their standards, as the birth-rate 'bulge' will reach them in the middle 1960's and the required intake in 1967 will form a rather smaller proportion of the number of persons of 18 years of age in the whole population than it did in 1957.

Sir Eric James, high master of Manchester Grammar School, then dealt with the place of science in the school curriculum. Science, he claimed, is no longer a specialized study, since it now influences the whole of human activity: it is raising our material standard of life, it is affecting the organization of society, it enters into economic and political issues, and it has shaken the foundations of philosophical thought and religious belief; and the scientist finds his spiritual satisfaction in its pursuit. It follows that science must now be a 'core' subject in the curriculum, as are English and mathematics, and that every child should do a course of elementary physics, chemistry and biology in the first five years of his secondary school course up to the standard of the Ordinary Level of the General Certificate of Education. The present condemnation of over-specialization is to some extent misguided, but what is to be condemned is the practice of early specialization, which means that some pupils give up science two or three years before they get to the sixth form.

When they reach the sixth form, those who want to become scientists will rightly spend most of their time on science subjects, including mathematics, but in view of the fact that scientists will have an increasing responsibility for shaping policy in industry and in Parliament, it is necessary that they should continue the study of English, history and a foreign language. It is equally important that those who elect to specialize in the humanities should continue the study of science in the sixth form. The elementary formal science that they have already learned should be supplemented by a course designed to teach the aim and method of science and its social implications. Such pupils will afterwards be better able to understand and work with scientists. We have much to learn about the most suitable course for specialists in the humanities, but these ends can perhaps best be attained by an account of the aim and method of science, illustrated by a rigorous treatment of the development of one or two of the great scientific generalizations. There should also be a less rigorous treatment of some of the recent developments of science such as atomic energy, modern theories of valency and antibiotics. But the limiting factor in achieving all this is an adequate supply of teachers of good quality.

Miss E. M. Huxstep, headmistress of Chislehurst Grammar School for Girls, said that girls spend less time on science than boys in their five-year course of elementary general education from 11 to 16 years of age, and a much smaller proportion of girls choose to specialize in science in the sixth form; there is thus less science accommodation in girls' than in boys' schools. This is partly the result of social convention, and partly because girls tend to be interested in persons rather than in things. Moreover, the careers arising out of science are less attractive to girls because they will meet stronger competition from boys in them than in many other professions, and because they cannot so easily resume work in science after they have married and brought up a family. Miss Huxstep felt that more girls could profitably be encouraged to specialize in science in order to play a part in meeting the country's need for more science graduates. Here again, however, the limiting factor is the supply of science mistresses of good quality entering girls' grammar schools to-day, some of which receive no applications even for a senior science post.

It was appropriate that the Conference should next turn to the supply and quality of science teachers and the sort of laboratory accommodation and equipment available in schools. Dr. A. W. Barton, headmaster of the City of London School, referred

to the creation by the Education Act, 1944, of the secondary modern school, which was to do for the average child what the secondary grammar school is doing for the child with academic ability. It took the secondary grammar schools fifty years to establish themselves, and it will take the secondary modern schools as long or longer, since, unlike the grammar schools, they have no earlier foundations on which to model themselves. But the Ministry of Education, local education authorities and teachers have not only had to try to staff these schools with a suitable variety of teachers capable of devising suitable four-year courses of instruction in various subjects for the average child of 11–15 years of age, but they have also been faced with the birth-rate 'bulge', which will increase the secondary-school population from 2,000,000 in 1950 to 2,900,000 in 1961. The necessary 30,000 extra teachers have been found, but the classes in primary and secondary schools are still too large and there is a shortage of specialist teachers for the secondary modern schools in such subjects as housecraft, handicraft, music and physical education; many of the existing specialist teachers are not fully qualified.

Dr. Barton insisted, however, that none of these subjects is so important in improving industrial output as the science taught in grammar schools and to that small proportion of children in secondary modern schools which takes the General Certificate of Education at Ordinary Level in science and mathematics. The extra 10,000 science graduates each year called for by the Government will have to come from these schools, and it is therefore essential that they should have good science staffs and accommodation. What are the facts? Before the Second World War the grammar schools were well staffed; all their posts were filled with graduates, 15 per cent of them with first-class, and 45 per cent with second-class honours degrees. To-day, 1,100 out of 7,160 such posts are either unfilled or unsatisfactorily filled, 614 of them with non-graduates. Before the War, public schools could recruit Ph.D.'s and men with first-class degrees to their science posts, but to-day more and more men with only third-class honours or pass degrees are being accepted. The secondary modern schools are in just as bad a plight: in 877 such schools providing courses for the General Certificate of Education in science and mathematics, there are 1,793 posts either unfilled or unsatisfactorily filled, including 1,375 occupied by non-graduates.

Dr. Barton gave four reasons for this serious deterioration in the scientific staffing of grammar schools since 1939. More science teachers are required to deal with the larger sixth forms; the universities, the Government and industry are using more scientists than in 1939, so that there are now not enough to go round; the salary offered to science teachers no longer compares favourably with that paid by other professions open to them, and work in the maintained grammar schools is no longer so attractive as it used to be. He suggested four further steps which should be taken to improve the science staffing of grammar schools. Arrangements should be made for distinguished head masters and science masters to put the claims of teaching as a career to third-year science undergraduates; undergraduates should be invited to spend a month in schools during their long vacations to see if teaching appealed to them. Before the War, the grammar-school teacher received a salary comparable with that of a university lecturer, whereas to-day it is £500 a year less; increases in salary should be granted to restore the pre-war position. An inter-departmental committee should be set up to ensure that the distribution of scientists among the bodies using them is in the best interests of the country.

Dr. H. F. Boulind, lecturer in education in the University of Cambridge, emphasized that science establishes its facts by observation and experiment, so that demonstrations in a lecture room and experiments in a laboratory are an essential part of science teaching. While the quality of the teacher is the important factor in determining how much progress a class makes, poor accommodation, absence of laboratory technicians and poor apparatus could discourage a good teacher and force him to waste valuable time on matters of routine. Less than half the maintained grammar schools are provided with adequate lecture rooms and laboratories, judged by the standards of the Ministry of Education; none is adequately provided by the standards of the Industrial Fund. The public schools, on the other hand, will all shortly be brought up to the Industrial Fund's standards by the generous financial assistance from the Fund. More than three-quarters of the maintained grammar schools are inadequately provided with laboratory technicians, including one-quarter which have none. Ten shillings per annum per pupil doing science is regarded as the absolute minimum for the provision of apparatus and consumable materials such as chemicals for efficient science teaching. Almost half the maintained grammar schools receive only eight shillings, and one or two receive as little as one shilling. The secondary modern schools are even worse off than the grammar schools in all these respects.

Dr. J. W. F. Hill (chairman of Lincoln City Education Committee) and Dr. B. E. Lawrence (chief education officer, Essex County Council) confirmed that local education authorities are trying to improve the situation by implementing some of the remedies proposed. They suggested that better teachers would be attracted to the profession if they were afforded the facilities for consultant work or research. It is claimed that in twelve years since the War £13½ million have been spent on science accommodation and equipment in some 3,000 grammar and secondary modern schools. How little this represents becomes clear when these figures are compared with the £3 million spent by the Industrial Fund on 180 public schools in three years using an improvized staff.

Dame Kathleen Lonsdale quoted figures showing that a greater proportion of women science graduates take up teaching than men, so that the universities could help by encouraging more women to read science, and, if necessary, enabling them to begin science at the university. She also felt that a greater proportion of all science graduates would take up school teaching, if it becomes the practice for all undergraduates to start at the university at 17 years of age and take a general honours course in three science subjects, to be followed by university teaching and research for the ablest and teacher training for those who want to take up school teaching.

Dr. D. R. Chesterman (warden, Goldsmiths' Training College) described how better grants for training college students have led to a large increase in the number of recruits for a three-year course, which includes enough physics, chemistry and biology to make a satisfactory science teacher for the average secondary modern school. He also thought that the three-year general honours-degree course in

physics, chemistry and biology, together with a one-year diploma course already provided by one or two training colleges, will provide some 100 science graduates a year, who will do good work below the sixth form in grammar schools and secondary modern schools.

In the course of the discussions which followed, Sir Graham Savage, formerly senior chief inspector of the Ministry of Education, pointed out that in the next three years some 500 naval officers will be retiring from the Royal Navy as a result of its reorganization programme. All these officers have been to a first-class school, Dartmouth, and then to the Royal Naval College, Greenwich, and are graded by the Burnham Committee as graduates. He was disappointed that the Ministry of Education expects these men to take a two-year course at a teachers' training college with students twenty years younger than themselves before allowing them to teach in schools, and he was afraid that some 300 promising teachers will thereby be lost to the schools, as it is unlikely that men of 40 years of age will be willing to take two years further training in order to teach. He appealed to the Ministry of Education to do for these men what it did for a body of ex-Service men after the Second World War by arranging a one-year emergency training scheme for them. Sir Gilbert Flemming, Permanent Secretary to the Ministry of Education, said that the deterioration in the standard of staffing of the grammar schools since 1939 is due to the fact that they are now trying to do more than they did before the War.

In the final discussion Sir Raymond Priestley pleaded that these defects should be remedied by spending more on education. At the opening session of the Conference, Sir Ben Lockspeiser expressed the hope that some action would result from the Conference. At the conclusion of his address, Dr. Barton hoped that the British Association would appoint two deputations: one to seek an interview with the Minister of Education to urge him to make the grammar schools his first priority in the next five years, and the other to seek an interview with the Lord President of the Council to ask him to set up an inter-departmental committee to find the facts about the distribution of scientists among the various bodies which use them, and to advise on what steps may be necessary to ensure that their distribution is in the best interests of the nation.

A. W. Barton

OBITUARIES

Dr. W. J. Arkell, F.R.S.

William Joscelyn Arkell was born on June 9, 1904, and was educated at Wellington College and New College, Oxford, where he took first-class honours in geology in 1925. He thus began the studies in Jurassic stratigraphy and palæontology which were to gain him an international reputation.

During 1929–33 he was lecturer in geology, and during 1933–40 Research Fellow at New College. From 1941 until 1943 he was with the Ministry of War Transport; a serious illness left him partly disabled, but although his hours of work had to be restricted and his field-work reduced, he returned to his scientific research, and few except his intimate friends realized the disadvantages under which he produced a steady stream of results. In 1947 he was elected a Fellow of the Royal Society, and a Research Fellow of Trinity College, Cambridge, where he worked at the Sedgwick Museum until a severe stroke in 1956 left him partially paralysed. But with the same courage and determination as he had shown after his first illness, he continued his work and wrote to his many correspondents from all parts of the world, showing his usual mental alertness, until a second stroke was followed within a few hours by his death on April 15 last. His last manuscript had been completed a few days previously.

Arkell's choice of subject for research was in part governed by his intense love of the English countryside, particularly of Cumnor, Oxford (where he lived), and of the Dorset coast where he stayed for part of each year. He enjoyed the thorough intimacy with the country which detailed geological mapping entails. He collected his first fossils around the home of his boyhood at Highworth, Wiltshire. His interest in Oxford and Dorset bore fruit in his "Geology of Oxford" (1947) and "Oxford Stone" (1947), and "Geology of the Country around Weymouth" (*Mem. Geol. Surv.*, 1947). His "Jurassic System in Great Britain" (1933), an informed, critical and exhaustive summary, exhibited his grasp of all aspects of stratigraphy and became at once an indispensable handbook; and his three monographs of the Palæontographical Society ("British Corallian Lamellibranchia", 1929–37; "Ammonites of the English Corallian", 1935–48; and "The English Bathonian Ammonites", begun in 1951, with the final part still in manuscript) are the work of one who had not only a keen grasp of the problems of systematic palæontology but also was familiar with the specimens in the field. He summarized his conception of the systematic relations of Jurassic ammonites in his section of the "International Treatise on Invertebrate Paleontology" (1957).

As his reputation grew, Arkell was asked to examine collections of Jurassic ammonites from many parts of the world; and the knowledge gained thus and by visits abroad was incorporated in his "Jurassic Geology of the World" (1956), a critical, informed and provocative summary and discussion. He had thus brought together his considered opinions on the Jurassic system and Jurassic ammonites before his death at the age of fifty-three. Much further research had been planned.

His interests were wide, and his publications by no means confined to the Jurassic; as an example, his work in collaboration with K. S. Sandford on Palæolithic man and the Nile valley (1929–33) should be mentioned.

His prose style was clear, precise and apparently effortless, qualities which sometimes gave his adverse criticism a sharper edge than he intended. But he was quick to encourage and to praise the younger generation, and although reserved, was a good friend.

A. G. Brighton

Dr. Paul Rivet

The death on March 21 of Dr. Paul Rivet has terminated a long and distinguished career in the anthropological study of the New World. He was born in 1876, and his early training was in medicine. He took part as medical officer in the French geodetic expedition to measure an arc of the meridian in Ecuador between 1899 and 1906, and this determined his future career. He became interested in the archæology and ethnology of the country, and this laid the foundation of the knowledge and love of Latin America which made him a revered figure throughout the area. His work during the expedition resulted in the publication with Dr. R. Verneau of "Ethnographie Ancienne de l'Équateur", which still furnishes useful information about that little-known country.

In 1908, he was appointed deputy director of the Anthropological Laboratory of the National Museum of Natural History, Paris, and some years later he became director of the Musée d'Ethnographie du Trocadero, which grew up under him into the Musée de l'Homme, so that he was able to refer in 1947 to that great building as "this house for which I worked for thirty years". Too soon after its opening in 1938, he was removed from his post by the Vichy Government, and after a time his activities as an organizer of resistance got him into trouble with the authorities and he had to flee overseas. He remained in Latin America, chiefly in Mexico and Colombia, for the rest of the War, to return to his post in triumph at its conclusion. He retired in 1947.

This is not the place to write of Rivet's political activities, except to say that his influence stood him in good stead in the organization of the 28th International Congress of Americanists in Paris in 1947. At the previous congress in Mexico in 1939, it had been resolved that the next one should be in Paris. A lesser man might have been daunted by the difficulty of organizing a congress in post-war France at that time; but Rivet seized the opportunity, and by arranging that the delegates should be entertained by the President of the Republic, the National Assembly and the Municipality of Paris, he set a standard which few countries could emulate, and showed that French anthropology was full of life in spite of the country's troubles. The Americanist Congresses, which normally take place every two years, owe much to him, and for many years he held high office in them. He was a great orator, and his speeches at these Congresses, particularly as president of that held in Paris, will not soon be forgotten by the delegates. He was prominent in Unesco and other international organizations. He has justly been described as for many years the heart and soul of the Société des Américanistes de Paris, of which he was secretary-general and editor of the *Journal*.

His reputation in Latin America was vividly shown by his reception in Lima in 1951, when he represented his country at the first International Congress of Peruvianists. At the age of seventy-five he was able to stand the strain of flying up to the great altitude of Cuzco at the end of the Congress, when much younger delegates were judged unfit to do so, and on arrival he lost no time in continuing his researches on the Quechua language in the libraries of that ancient city, in connexion with his great compilation of a complete bibliography of everything that has been written in Quechua and Aymara.

Rivet's numerous contributions to anthropology include papers on ethnology and physical anthropology, but the greatest number, spread over nearly fifty years, are connected with South American languages. He believed that there were relationships between the Malayo-Polynesian and Australian languages on one hand, and certain South American ones on the other, and he also maintained that there were actual migrations of both races to South America. He held that the Australians came first, by way of some small islands and the Antarctic continent when its fringes may have been free from ice during the climatic optimum about six thousand years ago, a view with which most archæologists disagree violently. Another highly controversial matter was his persistent advocacy of an early "Lagoa Santa" race of Australian and Melanesian affinities in America. The reaction of many physical anthropologists to this is illustrated by the following quotation: "That able and clever partisan, Paul Rivet, promoted them [the Lagoa Santa skulls] to racial status in 1908 in connection with a description of 17 crania from rock shelters near Paltacalo in Ecuador. . . . The Paltacalo skulls have thus acquired a fuzzy aura of antiquity and the Lagoa Santa crania have become the homotypes of a new 'race' consisting of about 35 examples". In his later years Rivet tended to ignore the controversies and to speak as if his views were proved beyond doubt, an attitude which many of his colleagues found exceedingly exasperating; but they will not soon forget his enthusiasm, his energy and his friendly encouragement of younger men.

G. H. S. Bushnell

NEWS and VIEWS

Meldola Medal for 1957 : Dr. D. J. Manners

Dr. David John Manners has been awarded the Meldola Medal for 1957 by the Council of the Royal Institute of Chemistry, with the concurrence of the Society of Maccabæans, in whose gift it is. Dr. Manners graduated in Cambridge, where he began research in the Biochemistry Department in 1949, under Dr. D. J. Bell, where he investigated the molecular structure of glycogen by chemical, physicochemical and enzymic methods. During 1951 he visited the Institut Pasteur in Paris, to study microbiological techniques. After receiving the Ph.D. degree in 1952, he was appointed lecturer in chemistry in the University of Edinburgh. Dr. Manners has successfully applied periodate oxidation and enzymic degradation methods to the investigation of the fine structure of polysaccharides from protozoa, photosynthetic plants, freshwater and marine algae and from lichens. Studies on glycogen have continued, and methods for determining the degree of multiple branching in starch-type polysaccharides have been devised. He has also investigated the preparation and properties of several enzymes metabolizing carbohydrates, including β-glucosidases from barley and α-glucosidases from yeast. A survey of the enzyme systems in marine algae has been initiated,

with special reference to carbohydrases. Dr. Manners's current research includes work on the metabolism of human glycogen in pathological cases of glycogen storage disease, and of mammalian muscle glycogen during the development of rigor mortis. The specificity of enzymes catalysing the transfer of α- and β-glucosyl radicals to carbohydrate acceptors is also being examined.

Sir George Beilby Memorial Awards, 1957

THE administrators of the Sir George Beilby Memorial Fund, representing the Institute of Metals, the Royal Institute of Chemistry and the Society of Chemical Industry, have awarded one hundred and fifty guineas each to Mr. B. E. Hopkins, a principal scientific officer in the Metallurgy Division of the National Physical Laboratory, in recognition of his work in physical metallurgy, with special reference to the effect of alloying elements in high-purity iron on the mechanical properties at temperatures covering the tough-to-brittle transition range under tensile and notch impact conditions; and to Dr. E. C. Potter, of the Paint Research Station, Teddington, in recognition of his work on electrochemistry and the corrosion of metals, with special reference to the internal corrosion of power station boilers and the analysis of boiler waters for solutes at great dilution. Awards from the Fund are made to British scientists for distinguished work in such fields as fuel economy, chemical engineering and metallurgy, in which Sir George Beilby's special interests lay. In general, the awards are not made to senior investigators but are granted as an encouragement to relatively young men who have done independent work of exceptional merit over a period of years. The administrators intend to review the character, frequency and conditions of awards from the Fund, and have decided not to consider any further awards until early in 1960.

Institution of Mining and Metallurgy: Awards

THE Institution of Mining and Metallurgy has announced the following awards: The Gold Medal of the Institution for 1957 to Dr. J. F. Thompson, chairman of the International Nickel Company of Canada, for distinguished services to metallurgical science, research and practice, with special reference to the nickel industry; Honorary Membership of the Institution has been conferred on Mr. R. Annan for outstanding services to the mining industry and to the Institution; on Dr. F. Dixey for services to the science of geology and in particular of his work in reorganizing the Colonial Geological Surveys; and on Mr. M. A. E. Mawby for valuable services to the mining industry in Australia and to the Institution; 'The Consolidated Gold Fields of South Africa, Ltd.' Gold Medal for 1956–57 jointly to Mr. K. E. Mackay and Mr. J. D. Johnson for their paper entitled "The Development of the Bancroft Mine" (*Trans. Inst. Min. Metall.*, 66) and 'The Consolidated Gold Fields of South Africa, Ltd.' Premium of forty guineas for 1956–57 to Mr. J. Morison Caw for his paper entitled "Control of Air Pressures as an aid to Fight Mine Fires" (*Trans. Inst. Min. Metall.*, 66); The Arthur Claudet Student's Prize to Dr. J. K. Almond for his part-authorship of the paper entitled "Pulp Density Measurement with Ultrasonics" (*Trans. Inst. Min. Metall.*, 66); and The William Frechville Student's Prize to Dr. Barry Scott for his part-authorship of the paper entitled "Stratigraphical and Structural Ore Controls on the Slitt Vein at Heights Mine, Weardale, County Durham" (*Trans. Inst. Min. Metall.*, 66).

Royal Meteorological Society: Honorary Members and Awards

THE following have recently been elected to honorary membership of the Royal Meteorological Society: Prof. Tor Bergeron, professor of meteorology, University of Upsala, distinguished for his contribution to synoptic meteorology and climatology in relation to the polar front, and for his elaboration of the theory of the generation of precipitation through the co-existence of ice and water in clouds; Sir David Brunt, distinguished for his contributions in many fields of meteorology, particularly in his studies of radiation and in the dynamics of the free atmosphere; Mr. E. Gold, distinguished for his early studies of the radiation balance of the atmosphere and on barometric gradient and wind force and for his services to synoptic meteorology as president of the Commission for Synoptic Meteorology from its foundation in 1920 until 1947; Prof. Sverre Petterssen, professor of meteorology, University of Chicago, a distinguished synoptic meteorologist of the Bergen school and president of the American Meteorological Society; Sir George Simpson, meteorologist to Capt. Scott's antarctic expedition (1912–13), Imperial meteorologist, India (1907–20), director of the Meteorological Office, London (1920–38), author of influential contributions to the knowledge of atmospheric electricity, palæoclimatology, the radiation balance of the Earth and atmospheric aerosols.

The following awards have also been announced: the Buchan Prize to Dr. R. M. Goody for his outstanding contributions to the theory and observations of the absorption and emission of radiation in the atmosphere; and the Hugh Robert Mill Medal and Prize to Mr. L. C. W. Bonacina, whose interest in precipitation in Britain has covered a period of more than fifty years.

Science and the State

IN his presidential address to the Institution of Chemical Engineers on "Science and the State" on April 30, Sir Hugh Beaver emphasized the dominant part that science and technology have come to play in national policy, while the influence of the State in the lives of ordinary people and on the use of scientists and the direction of research is also increasing. The vital problem is how these two forces can be brought to operate jointly and purposefully to achieve success. Sir Hugh addressed himself to the question whether our present arrangements are adequate and effective to ensure that the State can mobilize to the full the resources of science. He distinguished four aspects: the production of an adequate supply of scientists and technologists; the promotion of adequate research; securing that the results of research are known and applied; and the furtherance of development. Sir Hugh was concerned mainly with the first two, and in discussing education, stressed the importance of science teachers, a continuing shortage of which would ultimately stultify all other efforts to increase our supply of scientists and technologists.

Sir Hugh maintained that in education we have no concrete national policy nor the national organization to secure one, and in regard to research he

was as critical of the Lord President of the Council's office as he was of the limitations of the Ministry of Education. Pointing out that the Department of Scientific and Industrial Research in practice deals only with a comparatively small part of the nation's research and that the bulk of research sponsored or paid for by the Government does not come under the Lord President, Sir Hugh again emphasized that no means exist to formulate or to secure a co-ordinated national policy of research. He did not discuss how this responsibility could be discharged, but expressed the opinion that neither the Lord President of the Council nor the Department of Scientific and Industrial Research is well placed to further a coherent policy of education, research, development and finance. We are not spending enough on research and we are also lagging in the application of its results, and both can be attributed in part to the absence of scientific training among administrators and legislators. The effective mobilization of scientific effort is a problem which requires immediate attention.

Underground Constructions in Sweden

In 1940 Sweden embarked on a series of underground works dictated mainly by the need to defend herself against possible air attack from Nazi Germany or the Allies. For some years the Government had been considering 'going underground'; a number of pilot schemes had proved successful, but the tremendous potential, both for civil and military use, of her underlying strata of igneous rock was not fully appreciated until the end of the Second World War. With solid rock strata just below the surface or outcropping, surface building in towns always involved heavy blasting or drilling. Eleven years ago the 'Swedish method' of rock drilling was made possible by the Atlas-Copco Company in Stockholm. With the advent of the new drill technique it became cheaper to build below ground than above. The secret of this technique lies mainly in the design of a new drill operated by compressed air. The whole drill, pusher leg and various steels, can be carried easily by one man. The effectiveness of the method can be seen in the construction of the Katarinaberget in Stockholm. This is a three-deck bomb shelter and car park with room for 20,000 people. Details of its method of construction as well as other underground buildings in Sweden have been described by Hugh Pitt in a recent issue of *Discovery* (**18**, No. 2; February 1958). In the same issue Com. C. H. Williams describes all the ships which have carried the famous name *Discovery*.

A New Journal of Geophysics

The first number of the *Geophysical Journal* (*The Geophysical Journal of the Royal Astronomical Society*, incorporating the Geophysical Supplement to the Monthly Notices of the R.A.S. Vol. 1, No. 1 (March 1958). Pp. 114. Published quarterly. Annual subscription: 60*s.*; 9 dollars; single issues: 20*s.*; 3 dollars. (London: Royal Astronomical Society, 1958)) replaces, and in fact incorporates, the *Geophysical Supplement of the Monthly Notices of the Royal Astronomical Society*. It is to be published regularly four times a year and it will contain original contributions on various aspects of geophysics similar to those which were published in the *Geophysical Supplement*. The scope of the contents, however, will exceed that of the original supplement and it is intended to publish brief review articles on modern developments in those subjects in which recent research has produced new and important data. At the same time it will give summaries of the proceedings of the more important meetings on geophysical topics, including the Geophysical Discussions of the Royal Astronomical Society itself. Thus, in the present issue there are summaries of symposia on gravity measurements at sea, palæomagnetism and fault plane conditions held in connexion with the recent Eleventh General Assembly of the International Union of Geodesy and Geophysics in Toronto.

Inspection of the original contributions, which embrace the Earth's interior, various aspects of seismology, gravity, terrestrial magnetism including palæomagnetism and the mechanical properties of rocks, demonstrates that the same high standard characteristic of its predecessor is well maintained. This, coupled with its wider field of interest, should ensure the success of this new venture since its contents will appeal to both academic and applied geophysicists. Finally, an innovation worthy of comment is the inclusion at the end of the number of the titles and summaries of all the original contributions translated into Russian.

National Museum of Wales

The annual report of the National Museum of Wales for 1956–57 (pp. 76+4 plates. Cardiff: National Museum of Wales, 1957) naturally gives prominence to a record of the jubilee celebrations of March 1957. On the fiftieth anniversary of the date on which the Charter of Incorporation was granted (March 19) there were broadcasts in Welsh and English on the Museum and its activities, and a reception attended by more than 800 guests. A jubilee exhibition was arranged and a booklet outlining the history of the Museum was published. A memorial plaque to the late Dr. V. E. Nash-Williams was also unveiled in March 1957. A renewed application to the Treasury for the necessary funds to begin a Department of Industry was unsuccessful, but it is encouraging to note that, nothing daunted, the Council has submitted a third application. The circular gallery is again free for temporary exhibitions and it is a tribute to the Director and his staff that seventeen exhibitions were shown during the year. At St. Fagan's the first floor of the new museum building has been arranged to show a cross-section of the Welsh folk collection, and statistics give details of the intra- and extra-mural services of the Museum Schools Service.

Museum and Art Gallery, Leicester

The fifty-first annual report of the Leicester Museum and Art Gallery for 1956–57 (pp. 43+4 plates. Leicester: The Museums and Art Gallery, 1957) reports many activities of this lively centre. The repairs to Newarke Houses which have been spread over so many years have been completed, and the Chantry House opened as a Museum of the Medieval History of Leicester. The Committee has obtained the tenancy of 50 St. Nicholas Street, and has taken steps, while plans for the use of the building as a teaching museum of Roman history are developed, to make the important Roman pavement in the basement available to the public. Plans for the completion of the Jewry Wall site were again postponed for financial reasons. The committee thanks Mr. P. A. H. Muschamp for his invaluable honorary daily work in the Entomological Department during the past thirty-eight years.

National Science Foundation Fellowships for 1958–59

THE National Science Foundation, Washington, D.C., has announced the award of 756 pre-doctoral graduate fellowships and 85 regular post-doctoral fellowships in the natural sciences and allied fields for the academic year 1958–59. Of the former, 186 awards were made to first-year students, 374 awards were made to students in the intermediate years, and 196 awards to those in their last year. The largest group of pre-doctoral fellowships, 178, was awarded in physics. In other fields the numbers of awards were: chemistry 158, engineering sciences 93, mathematical sciences 92, zoology 54, earth sciences 45, biochemistry 29, psychology 21, medical sciences 12, botany 12, genetics 12, anthropology 9, microbiology 8, biophysics 8, agriculture 5, astronomy 5, general biology 5. In addition, 10 awards were made in areas where the natural sciences converge with the social sciences. Of the regular post-doctoral awards, 32 were made in the life sciences, 18 in chemistry, 18 in physics and astronomy, 11 in the mathematical sciences, 2 in the earth sciences, 1 in the engineering sciences, and 3 in areas where the natural sciences converge with the social sciences. The awards are tenable at any accredited non-profit-making educational institution of higher learning in the United States or abroad. Pre-doctoral fellowships are worth 1,600 dollars for the first year, 1,800 dollars for intermediate years, and 2,000 dollars for the last year of study. Regular post-doctoral fellowships carry a stipend of 3,800 dollars. All fellowships include additional allowances for dependants, tuition, and other normal expenses.

A Palæolithic Site in Pretoria

AMONG a number of articles, reviews and correspondence in the December 1957 issue of the *South African Journal of Science* is one by Revel Mason on an early stone age (Later African Chelles-Acheul) site at Wonderboom South, Pretoria, on the southern slopes of the Megaliesberg. Unfortunately there is no fauna, and the age has to be settled on typological and technological grounds only. There is a very large number of artefacts, and the site seems to have been selected for considerations of hunting, as it commands one of the few gaps through the eighty-mile-long range. Just as the cave of Castillo in northern Spain owes its continuous use by prehistoric man to the hot springs which bubble up near by, which animals love, so a concentration of game at the few gaps over the Megaliesberg made hunting an easy matter.

Phenobarbitone Therapy in Epilepsy

SINCE 1912 the use of phenobarbitone as an anticonvulsant in cases of epilepsy has been widespread. In a recent issue of *The Lancet* (March 22) Dr. D. C. J. O'Connor presents some striking results obtained with a new preparation ('Spansules'; Smith, Kline and French Laboratories), consisting of coated granules from which the drug is stated to be released at a uniform rate in the body. Eighteen psychotic epileptic patients who had previously been receiving phenobarbitone in solution or tablet form (together with phenytoin and primidone in some instances) were given 'Spansule' phenobarbitone. Over a period of eighteen months, the incidence of convulsions was reduced from a high level virtually to zero, and the mental state of the patients was considerably improved.

Unfortunately, many objections can be raised, which to all intents and purposes nullify the value of the results obtained; some of these objections have been stated in subsequent correspondence in the same journal. As Dr. J. Penman points out (*Lancet*, March 29), eighteen is too small a number of cases, and the test should have been planned in the form of a double-blind controlled clinical trial with advice from a statistician. Furthermore, although the form of phenobarbitone therapy was changed, the phenytoin and primidone regimens were continued and the dosage of phenytoin in some cases increased, thereby introducing additional variables. In a further comment, Dr. D. Pirrie (*Lancet*, March 29) observes that the total amount of phenobarbitone administered to the patients was doubled during the experimental period (from 2·8 to 5·6 gr. daily) and that an essential control study using twice the amount of ordinary phenobarbitone was not undertaken. In a later letter (*Lancet*, April 19) Dr. J. W. Pearson notes that Butler *et al.* (*J. Pharmacol.*, 111, 425; 1954) found that there was no significant difference in blood phenobarbitone-levels when divided doses of ordinary phenobarbitone were given and when the same total amount of drug was administered in 'Spansule' form. It is therefore unlikely that Dr. O'Connor's results are due to the maintenance of a constant level of phenobarbitone in the blood. In conclusion, it should perhaps be stated that the improved mental condition of the patients is more likely to be accounted for by the reduction in the frequency of fits than the lower toxicity of 'Spansule' phenobarbitone. It is also well known that mental patients receiving continuous attention from medical and nursing staff almost invariably improve.

A New Species of *Protopitys*

J. WALTON has described a fertile shoot of a new species of *Protopitys*, under the name of *P. scotica*, from the Calciferous Sandstone Series of Dumbartonshire (*Trans. Roy. Soc. Edin.*, 63, 233; 1957). This material has furnished the first available information on the reproductive structures of what has hitherto been regarded by most investigators of fossil plants as probably a genus of Pteridosperms. The new evidence relating to the reproductive structures, however, is more suggestive of a pteridophytic affinity. Moreover, the range in spore size suggests that a trend towards heterospory, with megaspores and microspores, was in progress. The author has accordingly proposed that a new group of Pteridophyta, the Protopityales, be established to include *Protopitys*.

International Federation of Automatic Control

THE constitution of the International Federation of Automatic Control, which was founded in Paris in September 1957, has now been ratified by the national organizations of the following twelve nations, which have thus become members of the Federation: China, Czechoslovakia, Denmark, Italy, Japan, Norway, Poland, Roumania, Sweden, Switzerland, the United States and the U.S.S.R. Prof. E. Gerecke (Zurich) has been appointed treasurer. It is proposed to form technical committees on bibliography, on nomenclature, symbols and definitions, and on educational questions. These technical committees will be combined into three main committees of the International Federation, namely, on automatic control theory, on components and measurements, and on the application of automatic control.

A draft for the scientific programme of the first International Congress for Automatic Control, which is to be held in Moscow during June 25–July 5, 1960, was submitted by the vice-president of the Federation, Prof. A. M. Letov, Moscow, and was approved by the Executive Council. Further information can be obtained from the Secretariat of the International Federation of Automatic Control, c/o Verein Deutscher Ingenieure, 79 Prinz Georg Strasse, Düsseldorf.

Royal Society of South Africa

At a recent meeting of the Royal Society of South Africa the following were elected as officers and members of Council for 1958: *President*, Prof. E. Newbery; *Hon. General Secretary*, W. J. Talbot; *Hon. Treasurer*, N. Sapeika; *Hon. Acting Editor of the Transactions*, A. M. Talbot; *Hon. Librarian*, J. H. Day; *Members of Council*, A. J. H. Goodwin, S. H. Haughton, F. G. Holliman, R. F. Lawrence, W. J. Lütjeharms, S. M. Naudé, R. H. Stoy, C. L. Wicht, M. Wilson.

University News: Cambridge

The Calouste Gulbenkian Foundation, Lisbon, has offered £50,000 for the proposed new Churchill College (see p. 1359 of this issue of *Nature*), to endow three Gulbenkian Studentships at the College for graduates of universities outside the United Kingdom. It is proposed that two of the studentships should be tenable for three years undergraduate or postgraduate study at the College, and one should be a senior studentship tenable for one year's postdoctoral research.

London

Prof. C. A. Rogers, Mason professor of pure mathematics in the University of Birmingham, has been appointed to the Astor chair of mathematics, tenable at University College. For a note on Prof. Rogers's work see *Nature* (**174**, 953; 1954). He succeeds Prof. H. Davenport, who is going to the Rouse Ball chair in Cambridge (see *Nature*, **181**, 528; 1958).

Oxford

Further gifts towards the cost of the proposed new College at Oxford—which is intended to replace St. Catherine's Society and to accommodate 400 students, of whom up to half would be scientists, mathematicians and engineers—have recently been announced. The Mullard Company has offered £50,000 payable over ten years, and the Shell Petroleum Company has offered £25,000 payable over seven years towards the general funds of the College, with an additional £2,500 payable over the same period for the College library.

The Gulbenkian Foundation, Lisbon, has offered £42,000 to be used for restoring the fabric of the Old Bodleian Library, as part of the University's current campaign for the preservation of its historic buildings.

Announcements

H.M. King Baudouin, King of the Belgians, and H.R.H. Charlotte, Grand Duchess of Luxembourg, have graciously accepted honorary membership of the Iron and Steel Institute. They are joint patrons of the Institute's special meeting in Belgium and Luxembourg, which is being held during June 17–28 in conjunction with the Journées Internationales de Siderurgie, organized in connexion with the Brussels Exhibition.

Mr. T. A. Rogers has been elected president of the Institution of Mining Engineers for the year 1959–60, and will succeed Mr. H. A. Longden at the annual general meeting of the Institution to be held in London next January. Mr. Rogers has recently been appointed H.M. chief inspector of mines and quarries from June 1, in succession to Sir Harold Roberts.

Prof. J. T. Thijsse, professor of theoretical and experimental hydraulics in the Technical University of Delft, director of the Hydraulic Laboratory in Delft, and consultant to the Netherlands Government in all major water problems, has been awarded the William Bowie Medal of the American Geophysical Union.

The Royal Society has made the following appointments: Dr. P. M. B. Walker, of the Biophysics Research Unit (Medical Research Council), King's College, London, to the Royal Society Research Fellowship, to work in the Department of Zoology, University of Edinburgh, on the quantitative study of the chemical control mechanisms operating during growth and division; and Mr. N. Tebble, of the British Museum (Natural History), to a John Murray travelling studentship for 1958 to study the Atlantic and Pacific coast Polychæta in the United States.

The Reith Lectures for 1958, entitled "The Individual and the Universe", will be given by Prof. A. C. B. Lovell, professor of radio astronomy in the University of Manchester and director of the Jodrell Bank Experimental Station. Prof. Lovell will describe the universe as it is revealed by contemporary astronomical techniques and relate the findings of science to religious and philosophical views on the individual's place in the universe. The lectures will be broadcast in the B.B.C. Home Service on successive Sunday evenings at 9.15 p.m., beginning on November 9.

The Gulbenkian Foundation has offered to provide £30,000 to convert Fort Jesus, Mombasa, into a museum of East African history and archæology under the care of the Royal National Parks of Kenya. The building, which has been used as a prison, is a fine example of Portuguese colonial military architecture, and is substantially that built by Matheus Mendes de Vasconcellos in 1594 and restored by Francisco Seixas Cabreira in 1634.

The Institution of Electrical Engineers is holding an International Convention on Microwave Valves during May 19–23 at the Institution, Savoy Place, London, W.C.2. An exhibition of apparatus will take place concurrently. Further information can be obtained from the Secretary of the Institution at the above address.

A symposium on "Salinity Problems in Arid Zones", organized jointly by Unesco and the Iranian government, is to be held at the University of Teheran, Iran, next September. The title and an abstract of not more than 250 words of each proposed paper should reach the Natural Science Department, Unesco, before June 1. Complete text of all submitted papers is required by Unesco by or before August 1. Final papers should contain a maximum of 5,000 words as well as the necessary data, diagrams and tables.

NEW NATURE RESERVES IN BRITAIN

THE Nature Conservancy has announced the establishment of a new nature reserve on the Gower Peninsula in Glamorgan, together with the extension of existing reserves at Coed Tremadoc and Bridgwater Bay.

The south coast of the Gower Peninsula in Glamorgan forms one of the most magnificent stretches of limestone cliffs in the British Isles. The steep south-facing slopes have for long been known to botanists for their exceptionally varied flora. The reservation extends over about 115 acres in the south-west corner of the peninsula and includes a short stretch of the mainland cliffs together with Worm's Head—an off-shore 'island' which is separated from the mainland only at high tide. It is situated within an area of outstanding natural beauty (National Parks and Access to the Countryside Act, 1949) and has been established under a fifty-year lease from the owners, Mr. C. P. M. Methuen-Campbell and Mrs. E. G. Beynon. Negotiations are in progress for bringing further areas into the reserve.

Many sea birds breed on the cliffs and ledges of Worm's Head; while on the mainland a number of caves in the coastal cliffs contain the remains of animals and also man. It was in the Paviland caves, more than a century ago, that one of the oldest ceremonial human burials was discovered. The 'Red Lady of Paviland'—now known to have been a man—had been stained in red ochre (the symbol of blood and life). Animal bones belonging to the Pleistocene age recovered from some of these caves include the remains of horse, bear and ox, together with mammoth, woolly rhinoceros, elk, wolf and reindeer.

The reserve is of interest to geologists because it reveals a detailed rock succession in Lower Carboniferous sediments of both Visean and Tournasian age which is not to be seen elsewhere in South Wales. These limestone cliffs are also of great botanical interest in that they bear a rich flora characteristic of limestone; they also support a number of rare plant species which form part of a relict flora to-day found only on massive outcrops of Carboniferous Limestone in a few places on the western shore of Britain.

Access to the reserve is unrestricted, but those wishing to collect specimens of animals or plants, or to carry out research on the reserve, should apply for permission to Mr. P. Walters Davies, South Wales Regional Officer, The Nature Conservancy, c/o Department of Zoology, University of Swansea, Singleton Park, Swansea.

A further small area of 8 acres, which has now also been added to the Coed Tremadoc reserve (*Nature*, **180**, 78; 1957), comprises part of the more westerly cliffs behind the village of Tremadoc known as Craig y Dref and Craig y Castell.

These cliffs are mainly composed of a massive intrusion of dolerite, flanked by a more acidic igneous rock. The crest of the cliff bears an extensive and interesting woodland of dwarf oak. As at Craig Pant Ifan, the cliffs are vegetated, though open faces do exist, and on these there are a number of fine rock-climbs. The soil of the apparently untouched ledges and gullies is of great interest as it has a very considerable depth of accumulated humus of a kind not to be found elsewhere within the more disturbed woodlands of Wales. The humus is very unstable, and trampling on the ledges, gullies and fairly steep rock faces where it accumulates sets it moving very easily. The Conservancy, while permitting rock-climbing, wish to direct this activity to the least-vegetated part of the cliffs so as to keep intact the essentially native vegetation and soils of some of the ledges and gullies. Here it has the help and co-operation of the owner, Capt. Livingstone-Learmonth, the tenants of Pant Ifan, the Birmingham Cave and Crag Club and the Climbers Club in the reconciliation of the interests of nature conservation and rock-climbing, and to this end the Birmingham Cave and Crag Club and the Nature Conservancy have devised a "Climbing Code".

Access to the reserve is by permit only, and applications should be addressed to the Conservation Officer, The Nature Conservancy, Y Fron, The Crescent, Upper Bangor, Bangor. Permits for rock-climbing can be obtained from the honorary secretary of the Birmingham Cave and Crag Club, Mr. D. Snell, 29 Beacon Road, Wylde Green, Sutton Coldfield. It is requested that applications for such permits should be made by the secretaries of mountaineering clubs on behalf of their members, but individual climbers may obtain permits locally from Capt. S. T. A. Livingstone-Learmonth, of Tan-yr-Allt, Tremadoc, or from the Nature Conservancy's warden, Mr. Evan Roberts, Gwynant, Capel Curig.

The Bridgwater Bay nature reserve (covering some 6,000 acres) was established in 1954 under an agreement with the Somerset River Board. When approval was given in June 1957 for the erection of a nuclear power station adjoining the reserve at Hinkley Point, approximately 14 acres had to be excluded from the reserve to meet the requirements of the Central Electricity Generating Board. The recent declaration excludes this area, but brings into the reserve Fenning Island, which has been purchased by the Conservancy from the owner, Mr. R. S. Gliddon.

Fenning Island, which was shown on the Ordnance Survey map of 1886 as separated from the mainland by a broad tidal creek, had been joined to the mainland by the time of the 1902 revision. The present supply of shingle to the ridge fronting Fenning Island and the growth of the large creek which now almost severs it from the mainland suggest that the separation may be re-enacted. The area is covered with a close-grazed sward of common saltmarsh grass, *Puccinellia maritima*, and is subject to occasional tidal flooding. For some time the Conservancy has maintained on Fenning Island, with Mr. Gliddon's permission, experimental plots in connexion with the research work of its coastal study section. While it is not intended to include in the by-laws any restriction of access over Fenning Island, there is a grazing tenancy over the land, which means that it must be treated as normal agricultural land.

PROBLEMS OF THE HUMID TROPICS

THE Eighth Session of the General Conference of Unesco authorized the Director-General "to promote the co-ordination of research on scientific problems relating to the humid tropical zone and to promote international or regional measures to expand such research". Under this Humid Tropics Programme, a symposium was held at Kandy on methods of study of tropical vegetation in 1955 and a report published; the symposium of wider scope held in Bangkok in November–December 1957 has been reported at length in *Nature* (**181**, 596; 1958). Another obvious first step was to collect information on problems in the tropical regions of member States. Accordingly, three general reports* were commissioned, to be based on available published literature, on the Amazon, the Caribbean, and South Asia, and are now published together with three special reports on biological problems in the Belgian Congo (G. Marlier), entomological problems in South Asia (A. P. Kapur) and water-power in the Philippines (F. C. Rodriguez).

It is difficult to say to whom the general reports are addressed. Dr. F. C. Camargo gives a simple yet interesting account of the Amazon basin, but many of his general statements will be questioned—that the Amazon territory includes examples of all known geological formations, that shifting agriculture is "vicious" and that the Koeppen system of climatic classification should be adopted exclusively. Whereas Camargo ignores much recent work and gives only a dozen references, mainly to local publications, Dr. E. Beltran, on the Caribbean, prints a bibliography of nearly 300 items. It is obviously impossible in the space of eleven pages to give other than a most elementary picture of one of the most complex areas in the world.

It is indeed a sad reflexion of the neglect of geography in the educational system of so many countries that what should be background knowledge of any educated citizen has to be the subject of a special report to Unesco. Similarly, apart from lists of tree species, there is nothing in the account of South Asia which does not form part of an undergraduate geographical course on the monsoon lands. Dr. Marlier's five pages on tropical Africa deal only with generalities and have no references, whereas Dr. Kapur's review of entomological problems is a detailed and informative survey of the present position, fully documented by a bibliography of 376 items. Although Dr. Rodriguez's survey of water-power resources and development in the Philippines, with a folding map showing all sites, seems strangely out of place in this collection, it, too, makes available information not readily accessible.

The editing of the volume is very poor. Innumerable sentences do not even make sense. What, for example, is meant by "*Zizyphus* are in good order" (p. 47), or "the principal vegetation region is Eugenia" (p. 47)? Generic names are sometimes given in small letters, sometimes with capitals; misprints such as "depterocarpaceae" are numerous. The map, Fig. 2, has no key, no scale, no orientation; Figs. 4, 5, 6, 7 and 8 have no scale; the vegetation map, Fig. 6, is described as "Distribution of Climatic Types" and the key is incomplete.

L. DUDLEY STAMP

* Problems of Humid Tropical Regions. Pp. 102. (Humid Tropics Research.) (Paris: Unesco; London: H.M. Stationery Office, 1958.) 900 French francs; 15*s.*; 3 dollars.

EXTREMELY HIGH TEMPERATURES

CONFERENCE IN BOSTON

A CONFERENCE on "Extremely High Temperatures" was held at the New England Mutual Hall, Boston, on March 18 and 19, and was attended by more than 400 members. The Conference was sponsored by the Electronics Research Directorate, Air Force Cambridge Research Center, Bedford, Mass., and members were welcomed by Dr. Lowell M. Hollingsworth, director, Electronics Research. An introductory address was given by Dr. Heinz Fischer, conference chairman, who was assisted by Dr. Lawrence C. Mansur in making the excellent arrangements. The papers were distributed among four sessions: "The Production of Extremely High Temperatures"; "Methods of Temperature Measurement—Optical Radiation"; "Plasma Analysis"; and "Applications".

The production of high-temperature gas by magnetic acceleration was discussed by G. S. Janes and R. M. Patrick (Avco). When highly ionized deuterium in a cylindrical chamber without electrodes was accelerated towards the axis by an axial magnetic field, and velocities up to 20 cm./μsec. were observed; the influence of magnetic guide fields parallel to the axis and the direction of motion was also investigated. Upper temperature limits in the high-pressure discharge were discussed by Dr. Heinz Fischer (U.S. Air Force). Spark discharges produced by the discharge of a capacitor with minimum self-inductance were described; the spark-channel temperatures were calculated from the measured spectral radiation density. The gas temperature increased with pressure and reached a limiting value; reduction of inductance raised the limiting temperature. Approximately 250,000° K. was obtained in helium at thirty-five atmospheres with a 7 kV. spark and with a current density of 10^6 amp./cm.^{2}. The effects of electrically exploded wires and the ensuing discharge were described by William M. Conn (Max-Planck Institute, Würzburg), the later stages of the explosion being recorded photographically. Alan D. Morris and Willis C. Gore (Naval Air Test Center) presented an analysis of the thermionic direct current electric arc. Inductive energy storage as a tool for high-temperature research was discussed by H. C. Early and R. C. Walker (University of Michigan); for storing electrical energy in the multi-million

joule range, an inductor is more economical than a capacitor.

In the next session, investigations of temperatures of a thermal plasma in the range up to 20,000° K., using the Holtsmark theory of spectral line broadening, as well as a microwave thermometer for millions of degrees based on the theory of abnormal microwave transmission of high-temperature gases in magnetic fields, were described by J. E. Drummond (Stanford Research Institute). Radiation effects on Rankine-Hugoniot shock conditions were discussed by Hari K. Sen and Arnold W. Guess (U.S. Air Force), and a calculation of the radial distribution of photon emitters was described by Willard J. Pearce (General Electric).

The third session opened with a paper by E. I. Gordon (Bell Laboratories) on "Plasma Diamagnetism as a Diagnostic Technique". This was followed by a mathematical analysis of thermal diffusion at high temperatures in ionized gases by S. Chapman and E. Tandberg-Hanssen (High Altitude Laboratory, Boulder). Types of plasma motors were discussed by W. H. Bostick, and the design of a megatron, a plasma accelerator of the pulsed air-core betatron type (megagauss betatron), was outlined by D. Finkelstein (Stevens Institute of Technology). Experiments in plasma acceleration accomplished by the exploding wire ejection technique at low pressure were described by T. Korneff and J. L. Bohn (Temple University); the wire between two parallel copper guides becomes the source of ions when a capacitor bank is discharged through it.

In the last session, on applications of plasma physics, a survey of problems of fusion propulsion was given by M. Clauser (Ramo-Wooldridge Corporation), and the feasibility of a thermonuclear propulsion system for, say, a future inter-planetary rocket with a 2,000 lb. pay-load was explored. A paper describing a high-temperature plasma generator, as well as some researches using this, was given by M. L. Ghai (General Electric). The plasma was obtained by high-temperature arc discharges using as much as 4,000 kW. of direct current power. A propulsion system using magnetic compression of the working fluid was analysed by A. E. Kunen and W. McIlroy (Republic Aviation), and a paper, mainly mathematical, on stochastic derivation of generalized macroscopic equations of change for reacting plasmas at extreme temperatures was read by H. J. Kaeppeler (Stuttgart). The behaviour of materials subjected to ultra-high temperature environments was described by J. H. Bonin and C. F. Price (University of Chicago); during the re-entry phase, hypersonic vehicles are exposed to high heat-flux rates, and to simulate these rates high-power arcs were used. An interesting cine-film was shown of the behaviour of materials such as aluminium, stainless steel, copper, nickel, nylon and graphite under these conditions. Finally, M. A. Levine (U.S. Air Force) described interesting developments in the design of force-free coils in producing strong magnetic fields to meet the problems of thermal effects and of the Maxwell stress tensor effects of the coil.

CHILDREN AND SOCIETY

THE British National Conference on Social Work is a voluntary organization which, since its inception in 1948, has taken the view that social work is an integral part of the effort made by the community to secure a better life for all. Membership of the Conference is open to any national social work agency in the United Kingdom, whether statutory or voluntary, which is in sympathy with its principles and aims. There are at present eighty voluntary and statutory bodies associated with the Conference.

It has two primary purposes: first, to convene—usually at intervals of three years—a national meeting to study specific social questions; secondly, to act in the United Kingdom as the national committee of the International Conference of Social Work, and in this capacity it is responsible for mobilizing interest in, and support for, international social service.

The third in the series of national meetings was held at Edinburgh during August 11–14, 1957, on the general theme of "Children and Young People". Many months in advance of the Conference, 158 study groups throughout the United Kingdom had considered a number of questions which had been put to them, and reviewed the post-war educational and social provisions made for children and young people. The views and findings of these study groups were made available to all members of the Edinburgh Conference*.

The Conference was attended by some 600 delegates and observers, including 40 visitors from overseas. Among those present were representatives of government departments, local authorities, teachers of social work at universities and schools, industrial personnel officers, officers of national voluntary organizations, and social workers from cities, towns, rural areas and new communities.

The relationship of children to their homes was examined by Prof. R. Ellis, of the University of Edinburgh, who mentioned three points of special interest. First, the long period of maturation of the human child, the learning of skills in the protective media of the family, and character formation as a positive imitation of what the child saw in the family circle. He also suggested the ingredients of the ideal home. Among those were regular employment for the father, the mother not forced to go out to work for economic reasons, and no focus of infection or discord. Mrs. Jean Mann, M.P., reminded the Conference of the number of deprived children in the care of local authorities, while Prof. Alan Moncrieff, of the University of London, and chairman of the Conference, discussed children who were maintained without payment by relatives and others. Nobody knew how many there were; the statutory authorities were reluctant to promote legislation; he believed some of those children were treated as little household slaves. When the time came to have a new Children and Young Persons Act, it should be possible to introduce some sort of registration and supervision of these children. A large body of miserable children belonged to that group, and this may be because family life is more fluid than it had been in the past, due to the emancipation of women. On housing estates or in blocks of flats there . . .

* "Children and Young People". (National Council of Social Service, 26 Bedford Square, London, W.C.1.) 5s. 6d.

be some provision for leisure-time activities where children could play and make a noise. In some new blocks of flats there should be a room available which children could use as a play centre. As a nation we were not doing an effective job with and for teenagers. Parents did not seem able to manage their teenage boys and girls, particularly girls. Mothers were not able to get on with their teenage daughters—could not make friends with them; that was why there were so many 'beyond control' and 'care and protection' cases coming into the courts.

Mr. T. H. Hawkins, of Birfield, Ltd., suggested that while industry had a great deal to answer for in the way it had adversely influenced character formation in many young people, there had been great changes since the War, and to-day there were many employers who are not only concerned with their primary purpose of running successful businesses and making profits, but also recognize that their organizations have a social function to perform.

This point was supported by Miss F. Hornbrook, of the Ministry of Labour and National Service, who said that the firms where young people liked to work were those with good management, good working conditions, good training schemes and a good reputation in the neighbourhood.

In an address on young people and leisure, Sir Ben Bowen Thomas suggested that young people to-day should be approached on the assumption that old social and economic divisions are on their way out, that community life is being articulated afresh, and that leisure activities are destined to hasten the process. Human relationships must conform increasingly to new social assumptions, social stratification counting for less and human association for more. "There is a threat only if we fail to humanize leisure. It holds an infinite promise of cultural creativeness and human happiness if we succeed. If we are to be worthy of our dealings with young people who seem to be destined, in spite of great perils, to enter a world of fabulous possibilities, we must believe that leisure can be a means for cultured and civilized living for increasing numbers and that if our efforts are aimed at dealing with the spirits of young people in terms of their highest potential, we can help them to grow as human beings who will be equal to the moral requirements of their great estate".

OUTPUT OF CHEMICAL ENGINEERS IN BRITAIN

REPLIES to a questionnaire sent by the Institution of Chemical Engineers to professors, heads of university departments, and principals of technical colleges in Great Britain regarding the present and future supply of chemical engineers and the difficulties experienced in obtaining suitable teaching staff, suggest that the country could provide 730 and 940 chemical engineers a year by 1959 and 1966, respectively, as compared with 277 in 1956.

The report "Scientific and Engineering Man-power in Great Britain" (H.M. Stationery Office, 1956) gives the total number of chemical engineers employed in Great Britain in 1956 as 1,500 and the total estimated number required by 1959 as 2,200—an increase of 47 per cent. The survey shows that the output from the universities alone should be sufficient to meet this requirement. At the time of publication of the report on man-power, the actual total number of graduate and corporate members of the Institution of Chemical Engineers in Great Britain was approximately 2,100, as compared with the figure of 1,500 given in the report.

The prospects in chemical engineering therefore appear to be good, but leave no grounds for complacency, especially when it is realized that the U.S.S.R., in relation to its population, trains three times as many professional engineers as the United Kingdom ("Engineering Education in the Soviet Union". Institution of Electrical Engineers, 1956). The estimates for 1959 appear to be somewhat optimistic, in view of the many difficulties in obtaining teaching staff described in the individual reports. These difficulties are real and widespread, and in general, rather worse in the technical colleges than in the universities.

The report on "The Supply and Training of Teachers for Technical Colleges" (H.M. Stationery Office, 1957) states that "for some years industry must be prepared to lose more than it may appear to gain. The help which is given in such large measure during the evenings by industrial scientist and technologist is invaluable. With the rapid growth of day courses, however, their help during the day time will become increasingly necessary".

University teachers of chemical engineering are not generally very hopeful about the expansion of part-time day teaching by members of the staffs of industrial concerns. What is needed in the universities and colleges of advanced technology is the secondment from industry to teaching duties of qualified men with experience of part-time teaching in the evening, for periods of not less than six months, without loss of seniority.

There is justification for more interest and support from industry, not only in the problem of the shortage of teachers, but also in the extension of student apprenticeship schemes, coupled with study for university degrees ('thick sandwich'-type schemes); diplomas in technology (sandwich courses); and Higher National Certificates (part-time day release schemes). Student-apprentice schemes involving attendance at university courses are expensive—there is considerable capital investment in each candidate without guarantee of a return. The slow development of Higher National Certificate courses which are comparatively cheap from the point of view of industry suggests, however, that much more encouragement could be given than is at present apparent without incurring great expense.

A vigorous research school is an essential feature of a fully developed chemical engineering teaching department. It is doubtful, however, whether it is justifiable to retain at college for chemical engineering research a proportion as high as one-third of those with first degrees as the estimates for 1959 and 1966 indicate. In 1953, approximately 22 per cent of the members of the Institution of Chemical Engineers were employed on research and development.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH, NEW ZEALAND

REPORT FOR 1957

THE thirty-first annual report of the Department of Scientific and Industrial Research, New Zealand, covering the year ended March 31, 1957*, comprises the Minister's statement, the report of the Council, the Secretary's report and brief reports from the several branches, to which are appended lists of publications of each branch during the year. The Minister's statement records the approval in principle of the establishment of a Nuclear Research Institute to be equipped with a high-voltage particle accelerator and, later, a research reactor at a total cost of about £500,000. Research grants to university colleges, agricultural colleges, the Cawthron Institute and other research institutions and learned societies amounted to about £140,000, and brief notes on work at the Cawthron Institute and the agricultural colleges are appended.

Gross expenditure for the year was £1,404,000 compared with £1,213,000 in 1955–56, and the staff increased from 928 to 946, but the Council points out that the proportion of the gross national product expended on research through the Department (which spends about half the funds allocated by the Government for scientific research and service) has fallen steadily since 1949–50, and in 1955–56 was 0·25 per cent compared with 1·3 per cent for the United Kingdom, 0·58 per cent for the United States and 0·52 per cent for Canada; per head of the population the corresponding figures are £1·16, £4, £4·9 and £3·2. The Council also regrets the failure of efforts to establish an organization for building research, because it is convinced that such an organization could improve housing conditions and lower costs of building. Whereas the Council does not recommend the establishment of a fuel and power institute as proposed by the Royal Society of New Zealand, it agrees that better facilities are needed for the co-ordination of development and research in this field.

Among the research results during the year to which the Secretary directs attention in his report are the development of a new general-purpose wheat *Aotea*, which gives a 22 per cent higher yield without sacrifice of baking quality of the flour. A considerable proportion of the Geophysics Division's activities during the year were devoted to the International Geophysical Year: the Division was responsible for the whole of the Antarctic and oceanographic programmes; the ionospheric programme at Christchurch, Campbell Island and Rarotonga; the seismological stations at Roxburgh, Wellington, Raoul Island and Apia; and the geodetic station at Wellington for measurements of latitude and longitude. The Dominion Physical Laboratory was also concerned with the development and construction of equipment for a unique study of radio propagation through the auroral zone and for the establishment at Invercargill of a composite station for the study of the aurora in all its aspects.

The Geological Survey, which will celebrate its centenary in 1964, when the International Geological Congress has been invited to hold its twenty-second congress in New Zealand, has commenced a study of the entire Buller Gorge area with the object of understanding its structure and the stratigraphy, frequency and nature of the uraniferous beds. Parallel mineralogical studies led to the discovery of the main uranium mineral, coffinite, hydroxyl-substituted uranium silicate, deposits of which are accompanied by pyrite, carbonate, hæmatite and fluorite. The geological map programme now contemplates as a first step publication of a wall-map of New Zealand on a scale of 32 miles to 1 in., data for which have already been compiled, followed by preparation of geological maps on a scale of 4 miles to 1 in. for the whole of New Zealand and its dependencies.

In nuclear science, radiocarbon dating was completed in ninety samples for Government departments, universities and museums, ten for overseas laboratories and thirty for the Department's own investigations. Anticipation of an enrichment of carbon-14 in the atmosphere as a result of hydrogen-bomb tests reported last year was substantiated, and the preliminary survey in the Wairakei, Rotura and White Island thermal area showed that sulphur in the geothermal area is isotopically different from sulphur in the vulcanic areas and both sources differ isotopically from sea-water sulphate. The analogue computer at the Dominion Physical Laboratory has been used to study the effects of earthquakes on ten-story buildings of different design, while work associated with the establishment of a radio-frequency standard for New Zealand has shown that the standard 16-kc./s. radio-wave transmitted from Rugby is outstandingly reliable as received in New Zealand. Intensive observations of geological and oceanographic factors in Cook Strait were made to assist in determining the flexibility of a power cable.

The Auckland Industrial Development Laboratories have devised equipment to produce a synthesized wave-form representing an arterial pulse which permits determination of the effect on the frequency-response of the change in stiffness of catheters and tubing with temperature or ageing. An automatic isodose computer and recorder has been designed which will rapidly plot a whole family of isodose curves in each plane in turn, and a fast-acting drip-rate recorder covering the range 5–80 drops a minute, developed to study the effect of intravenous administration of 'Pitocen' on uterine muscle activity. Following the tracing of spontaneous ignition in baled wool to pie wool, it has been demonstrated that removal of the animal fat removes the fire hazard, but the responsible factors in the fat have not been isolated. Complete control of spontaneous fires in wool ships has been gained by voluntary regulations within the industry, segregating pie wool for shipping and encouraging shippers to scour it.

Considerable work has been carried out to determine spray programmes which will not leave excessive poisonous residues on the fruit under the conditions obtaining in New Zealand. A new study of the relation between the degree of yeast damage and the relative proportions of flour, water, sugar and salts

* New Zealand. Thirty-first Annual Report of the Department of Scientific and Industrial Research, 1957. Pp. 84. (Wellington: Government Printer, 1957.)

present in brews has shown that a yeast toxin present in flour is active only with low concentrations of soluble salts. Measurements of the transpiration rates of mustard plants grown in a controlled environment indicate that the rate falls at a critical moisture-content, depending on the conditions but usually well before wilting point is reached. Soil surveys during the year included Chatham Island and two large islands of Western Samoa, while irrigation surveys of the soils of the Ida Valley and of part of the upper Clutha Valley were completed. In an investigation of the biology of native tussock grassland soils in North and South Islands, moulds, yeasts, actinomycetes, bacteria, protozoa, algae and earthworms were studied during the four seasons from the same soil sites.

A third grassland sub-station was initiated at Kaikohe, where a start has been made on testing strains and progenies as single plants and in pure and mixed swards to find the best cultural and soil fertility conditions. The study of the relation of seasonal grazing intensities to the amount of active plant tissue exposed to the light for photosynthesis is leading to a much better understanding of the effects observed on mixed pastures under various grazing regimes, while the Plant Chemistry Laboratory, using isolated chloroplasts of leaf cells as starting material, has prepared in highly purified form a protein which was then shown to be the coenzyme responsible for fixing carbon dioxide.

An insect survey has been commenced, initially in the North Island, to provide a firm basis for priorities in entomological research, and the Plant Diseases Division has published a text-book on "Plant Protection in New Zealand". Evaluation of earlier field observations has led to a better understanding of the biology of the European wasp in New Zealand, and the boron diffusion-impregnation method of treating timber developed by the Division has now been approved by the Timber Preservation Authority. The finding, in the autumn of 1956, on plant residues of brassica crops, of the perfect stage of the fungus causing dry rot of swedes is of major importance, giving a much better understanding of the spread of the disease and changing the whole approach to the problem of control. Trials during the past season have shown that diphenylamine used either as a dip or in wraps gives much better control of superficial scald on Granny Smith apples than oiled wraps, which should permit extension of the storage period and also save packing costs when it is used as a dip. Besides searching for tobacco varieties or strains resistant to verticillium wilt, the Tobacco Research Station has obtained good results in the field by soil treatment with chloropicrin and methyl bromide, but both are still too expensive.

Recent work of the Fats Research Laboratory has established the presence in hydrogenated ox-fat of n-fatty acids from C_2 to C_{26}, including the n-odd numbered fatty acids from C_3 to C_{23} except C_{11}; margaric acid has been isolated from butter-fat and in lamb caul fat acids with double bonds separated by two or more methylenic groups have been found. Good progress was made in the preparation of pure phosphatidyl choline and phosphatidyl ethanolamine from the lipids of beef muscle. A nine-months survey of rabbit habitats in New Zealand has been initiated to analyse in some detail the influence of vegetation, as related to rainfall, land use and soil conditions on the density of rabbit populations.

DIGITAL FIELD COMPUTERS

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MODERN digital computers are not particularly well suited to the solution of partial differential equations because of limitations of storage capacity and speed. For example, in computing the solution of Laplace's equation, $\nabla^2 V = 0$, for given boundary values, the field would be divided into a lattice of points, and the finite-difference approximation to the equation solved at all points. To take advantage of the precision and ability to estimate accuracy of a computer, it would—in a typical problem—not be excessive to demand 200 as the number of finite-difference steps to be used for one of the space co-ordinates. Over a 3-dimensional cubic field, this would require the storage of at least 8 million numbers, and for a 2-dimensional problem over a square field, 40,000. The latter is barely within reach of even large machines in Britain. Speed of computation in field problems is also poor. For example, on the Ferranti Mark 1 at the University of Manchester, the solution of a 2-dimensional problem involving the Navier–Stokes equations of fluid flow took 40 hr. of machine time. Slowness is due to the computing operations taking place in serial order in time, so that in—for example—elliptic differential equations like Laplace's the whole field of lattice points has to be gone over again and again until convergence sets in.

Therefore, the making of machines of larger storage capacity will not by itself be the answer to the problem of field computation. For this will actually increase the slowness by increasing the number of lattice points, although this effect can be countered to some extent by making a greater proportion of the storage of the fast-access type.

A kind of digital computation is therefore proposed which practically eliminates the speed limitation.

Taking Laplace's equation as an example, we know it can be solved by an electrical network analogue. For example, in the 2-dimensional case,

$$\frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} = 0$$

can be solved by applying the boundary potentials V to the appropriate nodal points of a rectangular-mesh network of equal resistors. Practically instantaneously, the currents adjust themselves so that the potentials at all the nodes satisfy the finite-difference form of this equation. This comes about through the operation of Kirchhoff's laws, namely, that the algebraic sum of the currents at every node is zero, and that of the potentials around every mesh is zero. But currents and potentials can be looked upon, for computing purposes, as numbers or rates of travel of numbers, and the arithmetical processes

mentioned are simple ones. Therefore, it should be possible to substitute for these physical quantities their digital representatives, namely, trains of pulses, and design a lattice of computer circuit units, which will, at each lattice point, carry out the required simple arithmetical operation or operations. One way of looking upon this example is to consider that one is substituting, for the physical flow of electrons through the network of resistors, the flow of pulses through a network of computer units. The advantage is the greater precision inherent in digital systems.

If this can be done, then the time taken by the process is of the order of the duration of the pulse train representing the largest number the system is designed to handle. For pulses of lengths and recurrence frequencies used nowadays, this would be anything from a fraction of a second to some minutes; in practice, it would probably not be necessary to go to very great lengths in attainment of speed, as the main limitation on speed would now be the means of reading off the answers at all or a selection of the lattice points. It is more to the point to draw from this property a practical advantage in design; it becomes feasible to represent numbers on a unitary instead of binary system, that is, the integral number N is represented by N pulses. This greatly simplifies the design of the lattice circuit units.

At Edinburgh, a basic unit has been designed and tested, which receives two inputs, one consisting of a train of N_1 pulses, the other of a synchronized train of N_2 pulses, and produces continuously a train of $\frac{1}{2}(N_1 + N_2)$ synchronized pulses. The successive pulses of a train may arrive with gaps, so that the input at a particular time may be 0, 1 or 2 pulses.

By suitably connecting three of these basic units together one can obtain a lattice unit with four pulse inputs, say V_1, V_2, V_3, V_4 and pulse output V_0 given by

$$V_0 = \tfrac{1}{4}(V_1 + V_2 + V_3 + V_4)$$

Since this is the 2-dimensional finite-difference form of Laplace's equation, a 2-dimensional array of these lattice units with output of each connected to one input of each of its four nearest neighbours will solve the corresponding potential problem, when trains of pulses of the correct total number are fed into the boundary units.

Similarly in the 3-dimensional case, by suitably connecting six basic units one obtains a lattice unit of 6 pulse inputs, giving

$$V_0 = \tfrac{1}{6}(V_1 + V_2 + V_3 + V_4 + V_5 + V_6)$$

The general potential problem can then be solved by a 3-dimensional interconnected array of such lattice units, since this is the finite-difference form of the general equation.

The basic units may be interconnected in various other ways to solve other field problems, but of course the proposed computer—and this is its main drawback—is not a universal machine. Other basic units would be necessary for other classes of field.

A major problem is how the answers should be read off. If mechanical counters geared to the outputs of lattice units are used, this would limit the speed of the computation and the latter—more importantly—would limit the accuracy. For with direct mechanical counting the interval between pulses would probably have to be at least 1/25 sec. If a computation is to be allowed to last, say, 15 min., this would mean a maximum number of pulses of $15 \times 60 \times 25 = 22{,}500$. That is, only about 5-figure accuracy would be possible. If one aimed at an accuracy of 8 significant figures, electronic counters like dekatrons would probably have to be used.

Not much can be said about cost. Success would depend on the availability of reliable transistors and semi-conductor diodes, as the power requirements for thermionic-valve circuits would be quite excessive. It may be possible to reduce costs by a large factor by arranging for blocks of lattice points to be dealt with by single lattice units in temporal order, with the aid of a switching device. As the lattice units are identical, they are amenable to mass-production, and it may be that field computers would therefore be intrinsically no dearer, and perhaps a good deal cheaper, to construct than conventional machines of the same capacity.

On the unitary system it does not matter when the boundary pulses are fed in provided their total number equals the correct potential, say. Therefore, once the solution for given boundary values has been found, it is easy to find the effect of additive changes in the boundary values: one has merely to feed in a few more pulses at the appropriate places. This is a facility of obviously great usefulness in engineering design.

A control unit would be required with the following functions: (1) to interconnect the basic units for the problem in hand; (2) to set the boundary pulse generators; (3) to set the counters; and (4) to read the counters and punch or teleprint the answers.

SPIN FUNCTIONALS

By Dr. J. AHARONI

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IT is well known that the Lorentz group possesses unitary representations of infinite dimensions only. Consequently, state vectors in quantum mechanics necessarily belong to Hilbert spaces of infinite dimensions. In such spaces it is possible to define a unitary scalar product of any pair of state vectors which remains invariant under Lorentz transformations. Let L be a Lorentz transformation and let U_L be the unitary operator in the Hilbert space representing L. When a Lorentz transformation takes place, any vector $\vec{\Phi}$ in the Hilbert space changes into $U_L\vec{\Phi}$ and for the scalar product $(\vec{\Phi}, \vec{\Psi})$ of two vectors $\vec{\Phi}$ and $\vec{\Psi}$ we have

$$(\vec{\Phi}, \vec{\Psi}) = (U_L\vec{\Phi}, U_L\vec{\Psi}) \qquad (1)$$

Hilbert spaces of infinite dimensions are associated with functions of variables possessing an infinite

range of values which may be continuous or discontinuous. Denoting these variables by q, we have

$$(\vec{\Phi}, \vec{\Psi}) = \int \varphi^*(q)\psi(q)\mathrm{d}\omega \qquad (2)$$

where $\mathrm{d}\omega$ is an invariant volume element in q-space.

Functions of variables which can take only a finite number of values are associated with Hilbert spaces of finite dimensions, and as no unitary representations of finite dimensions of the Lorentz group exist (apart from the trivial representation $U_L = \pm 1$) such functions cannot represent quantum mechanical states. In particular, it is not possible to look upon spin functions $U(s)$, $(s = \pm \frac{1}{2})$ as wave functions which describe spin states. Let U be a vector representing $U(s)$ so that $U_{\frac{1}{2}} = U(\frac{1}{2})$ and $U_{-\frac{1}{2}} = U(-\frac{1}{2})$. We can look upon it as a state vector only if we restrict ourselves to the group of rotations, as was done by Pauli when he first introduced the spin-variable in a non-relativistic wave equation. The reason for this possibility lies in the existence of a two-dimensional unitary representation of the group of rotations. If we go over to the Lorentz group, the two-dimensional unitary transformations must be enlarged to the two-dimensional unimodular group which is no longer unitary.

The only way of retaining the spin variable (or any other variable of finite number of values) without getting into conflict with the theory of relativity is to advance from the concept of a function to that of a functional, as is done by the principle of second quantization with ordinary wave functions. A functional of spin functions will yield the probability of finding any specified distributions of spins in the considered state, and not the probability for a given spin of a single particle. In other words, it will tell us the probability of finding a given number of particles with the spins up and another number with the spins down.

Functionals of spin functions may be constructed as follows. Let the spin function be given by:

$$U_{a,b}(s) = aU_1(s) + bU_2(s) \qquad (3)$$

where $U_1(s)$ and $U_2(s)$ are a complete set of orthonormal functions (in the unitary sense). For example,

$$U_1(s) = \delta_{\frac{1}{2},s}, \quad U_2(s) = \delta_{-\frac{1}{2}s} \qquad (4)$$

Then, any function $\varphi(a,b)$ will represent a functional of spin functions: for each pair of values a,b which determine a spin function $U_{a,b}(s)$, $\varphi(a,b)$ will yield a number. This number will represent the amplitude of probability of finding a particles with spin up and b particles with spin down. The state vectors will thus consist of vectors in a Hilbert space of functions of two variables, $\vec{\Phi} \to \varphi(a,b)$. We must demonstrate that in the Hilbert space of spin functionals unitary representations of the Lorentz group are possible. To this end, we define the scalar product as follows:

$$(\vec{\Phi}, \vec{\Psi}) = \iint \varphi^*(a,b)\,\psi(a,b)\,(\mathrm{d}_2 b\,\mathrm{d}_1 a - \mathrm{d}_2 a\,\mathrm{d}_1 b) \qquad (5)$$

Next, we note that a,b transform as two components of a spinor which undergoes a unimodular transformation when a Lorentz transformation L is performed:

$$\begin{aligned} a' &= \alpha a + \beta b \\ b' &= \gamma a + \delta b \quad (\alpha\delta - \beta\gamma = 1) \end{aligned} \qquad (6)$$

With each such transformation we couple the following transformation in the Hilbert space:

$$\begin{aligned} \varphi(a,b) \to U_L\varphi(a,b) &= \varphi(\alpha a + \beta b, \gamma a + \delta b) = \varphi(a',b') \\ \psi(a,b) \to U_L\psi(a,b) &= \psi(\alpha a + \beta b, \gamma a + \delta b) = \psi(a',b') \end{aligned} \qquad (7)$$

The equality of the scalar product in (5) and

$$(U_L\vec{\Phi}, U_L\vec{\Psi}) = \iint \varphi^*(a',b')\psi(a',b')\,(\mathrm{d}_2 b\,\mathrm{d}_1 a - \mathrm{d}_2 a \mathrm{d}_1 b) \qquad (8)$$

follows now from the invariance:

$$\mathrm{d}_2 b\,\mathrm{d}_1 a - \mathrm{d}_2 a\,\mathrm{d}_1 b = \mathrm{d}_2 b'\,\mathrm{d}_1 a' - \mathrm{d}_2 a'\,\mathrm{d}_1 b' \qquad (9)$$

The basic infinitesimal transformations of the Lorentz group, which define the angular momentum, induce in the Hilbert plane of spinors six infinitesimal transformations which lead essentially to the Pauli operators: $\sigma_{23} = \sigma_x$, $\sigma_{31} = \sigma_y$, $\sigma_{12} = \sigma_z$, $\sigma_{14} = i\sigma_x$, $\sigma_{24} = i\sigma_y$, $\sigma_{34} = i\sigma_z$.

In the Hilbert space of functionals the Pauli matrices will be represented by the operators

$$\begin{aligned} \sigma_x \to \Sigma_{23} &= a\frac{\partial}{\partial b} + b\frac{\partial}{\partial a}, \quad \sigma_y \to \Sigma_{31} = \frac{1}{i}\left(a\frac{\partial}{\partial b} - b\frac{\partial}{\partial a}\right) \\ \sigma_z \to \Sigma_{12} &= a\frac{\partial}{\partial a} - b\frac{\partial}{\partial b} \end{aligned} \qquad (12)$$

and corresponding operators for $\Sigma_{14} = i\Sigma_{23}$, $\Sigma_{24} = i\Sigma_{31}$, $\Sigma_{34} = i\Sigma_{12}$.

From the anti-symmetrical tensor Σ_{kl} and its dual we can form two invariants: $\Sigma_{kl}\,\Sigma_{kl} \equiv 0$ and

$$\begin{aligned} \Sigma^2 &= \frac{1}{i}\,(\Sigma_{14}\Sigma_{23} + \Sigma_{24}\Sigma_{31} + \Sigma_{34}\Sigma_{12}) \\ &= 4\left[\frac{1}{2}\left(a\frac{\partial}{\partial a} + b\frac{\partial}{\partial b}\right)\left\{\frac{1}{2}\left(a\frac{\partial}{\partial a} + b\frac{\partial}{\partial b}\right) + 1\right\}\right] \end{aligned} \qquad (13)$$

This represents the square of the total angular momentum (to a factor 4).

Creation and annihilation operators involve only two states, up-spin and down-spin. Since a spin 1/2 obeys Fermi–Dirac statistics, a and b can only be 1 or 0 in any given state and we have, for example,

$$A_1^*\,\varphi(0,b) = \varphi(1,b), \quad A_{-1}^*\,\varphi(a,0) = (-1)^a\varphi(a,1) \qquad (14)$$

The relativistic invariance of the anti-commutation rules which these operators obey is displayed when they are expressed in spinor form:

$$\begin{aligned} A_\mu A^\nu + A^\nu A_\mu = \delta_\mu^{\ \nu}, \quad A_\mu A_\nu + A_\nu A_\mu = 0, \\ A^\mu A^\nu + A^\nu A^\mu = 0 \end{aligned} \qquad (15)$$

where A_μ stands for A_1 and A_{-1}, and A^ν for A_1^* and A_{-1}^*.

For a spin 1 we must use functions of three variables $\varphi(a,b,c)$ corresponding to three values of the spin variable -1, 0, $+1$. The spinors here are of second rank and symmetrical, yielding a three-dimensional representation of the Lorentz group.

All the above can be extended to the isotopic spin and to four-spinors. The concept of a spin functional should prove useful in relativistic theories. Apart from this, it offers probably the simplest explanation of why the special theory of relativity forces us to abandon the single-particle model and to introduce the many-particle theory and the second quantization which is connected with it.

I wish to thank Prof. A. Salam for some discussions on the subject of this article.

BETA-OXIDATION OF OMEGA-(3-INDOLYL)ALKANECARBOXYLIC ACIDS IN PLANT TISSUES

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ATTENTION has recently been given in this laboratory to the plant growth-regulating activity of substituted fatty acids in relation to their oxidative degradation within plant tissues[1]. These investigations have now been extended to include 3-indolecarboxylic acid and its higher homologues. Of these compounds, 3-indolylacetic acid is well known as a highly active plant growth hormone and β-(3-indolyl)propionic, γ-(3-indolyl)butyric and δ-(3-indolyl)valeric acids have also been reported to be active in certain tests[2]. Though the activity of the butyric analogue is explicable in terms of breakdown of the side-chain by β-oxidation to yield 3-indolylacetic acid within the tissue, it is difficult to account for the reported activity of the valeric and propionic analogues, neither of which can yield 3-indolylacetic acid by β-oxidation.

The growth-regulating activity in the wheat cylinder, pea segment and pea curvature tests[3] of the first seven acids of the indole series, $C_8H_6N(CH_2)_nCOOH$, with $n = 0$–6, has now been determined, and the results are given in Table 1. It will be observed that with the exception of 3-indolecarboxylic acid, all homologues are highly active in these three tests. Although the behaviour of the butyric and caproic analogues is as expected on the basis of their probable conversion to 3-indolylacetic acid, the activity of the propionic, valeric and heptanoic acids cannot be so explained.

To investigate this problem, the breakdown of all these indole acids within plant tissue was studied by a technique which has already been used here in related investigations[3]. This involved treating solutions of the compounds for 24 hr. with wheat or pea tissue followed by ether extraction of tissue and solution and chromatographic analysis of the extract. 1,000 μgm. of each acid in 50 ml. 0·1 per cent aqueous acetone were treated at 25° C. with either one hundred 1-cm. wheat coleoptile segments or one hundred 1-cm. pea stem segments. After 24 hr., the tissue and solution were frozen overnight at − 10° C., and after thawing, the solution was extracted at *p*H 3·0 with three 50-ml. quantities of peroxide-free ether. The acid fraction was removed from the ether extract with sodium bicarbonate solution and after acidification taken back into ether. After drying over anhydrous sodium sulphate, the extract was concentrated to about 0·2 ml., and this solution was applied in successive drops to a spot on the starting line of a paper chromatogram (Whatman No. 1). This was developed for 10 hr. at 20° C. in the ascending manner using butanol/ammonia/water (200 : 6. : 36) as solvent. The paper was then dried and sprayed with Ehrlich reagent[4]. A second chromatogram was run at the same time in all experiments, using ether extracts of untreated solutions of each acid which had been allowed to stand in the incubator for 24 hr. at 25° C.

Typical results are illustrated in Figs. 1 and 2. In Fig. 1, showing untreated acids, 3-indolecarboxylic acid appeared as a pink spot of R_F 0·23. All the other acids gave blue colorations with the reagent and the R_F values increased in a regular manner with increase in molecular weight (Fig. 1).

The chromatograms obtained from metabolism experiments provided clear evidence that β-oxidation of the side-chain of these indole acids had occurred both in wheat and pea tissues. Thus, for example, from extracts of wheat-treated solutions (Fig. 2), a blue spot corresponding to the acetic acid ($n = 1$) was observed from butyric and caproic acids ($n = 3$ and 5), and furthermore, the caproic derivative also yielded the butyric acid. Similarly, a blue spot corresponding to the propionic acid ($n = 2$) was obtained from both the valeric and heptanoic acids ($n = 4$ and 6), the latter also producing the valeric acid presumably as an intermediate product. With extracts of both the metabolized valeric and heptanoic acids, a green spot (R_F 0·25) developed with Ehrlich reagent immediately above the position of the propionic acid (R_F 0·35). This unknown compound also appeared in extracts of the metabolized propionic acid (Fig. 2), and its infra-red absorption spectrum indicated the presence of a hydroxyl group (broad

Table 1. Growth-regulating Activity of ω-(3-Indolyl)alkanecarboxylic Acids* in the Wheat Cylinder, Pea Segment and Pea Curvature Tests†

Name of compound	Concentrations tested (molar)											
	Wheat cylinder test				Pea segment test				Pea curvature test			
	$\times 10^{-7}$	$\times 10^{-6}$	$\times 10^{-5}$	$\times 10^{-4}$	$\times 10^{-7}$	$\times 10^{-6}$	$\times 10^{-5}$	$\times 10^{-4}$	$\times 10^{-7}$	$\times 10^{-6}$	$\times 10^{-5}$	$\times 10^{-4}$
3-Indolecarboxylic acid	101	103	100	98	101	101	102	103	0	0	0	0
3-Indolylacetic acid	**111**	**156**	**160**	**155**	107	**121**	**120**	**119**	1	2	4	6
β-(3-Indolyl)propionic acid	103	102	**112**	**151**	100	101	**116**	**125**	0	3	5	6
γ-(3-Indolyl)butyric acid	**116**	**152**	**161**	**157**	105	**117**	**127**	**123**	2	4	6	6
δ-(3-Indolyl)valeric acid	102	102	**113**	**140**	102	102	**110**	**127**	0	1	4	6
ε-(3-Indolyl)caproic acid	**135**	**150**	**161**	**147**	105	**114**	**122**	**122**	2	4	6	6
ζ-(3-Indolyl)heptanoic acid	99	102	**134**	**149**	102	101	**108**	**128**	0	0	3	6

* All compounds were examined at the stated concentration of the acid in water containing 0·1 per cent acetone.

† The responses obtained in all tests were assessed after 24 hr. In the wheat cylinder and pea segment tests, activity is expressed as a percentage of the final length of control segments. Figures in heavy type are significantly different from controls at the 0·1 per cent level. In the pea curvature test activity was assessed using a scale from 0 (inactive) to 6 (highly active).

band $\lambda = 3{,}500$ cm.$^{-1}$) which may be attached to the ring, since a strong absorption also occurred at 1,390 cm.$^{-1}$. A bioassay of the chromatogram showed that there was no growth-promoting activity in the region where this compound occurred. Indeed, when chromatograms containing extracts of wheat- or pea-treated β-(3-indolyl)propionic acid were segmented into twenty transverse strips and each examined by the wheat cylinder test, only one zone of growth-promoting activity was revealed, and this coincided exactly with the region of the chromatogram containing the unchanged propionic acid.

In other metabolism experiments, the pattern of metabolites on the chromatogram as revealed by Salkowski reagent[4] was similar to that observed with Ehrlich reagent (Fig. 2). In neither case, however, was there any evidence in these experiments for the formation of N-(3-indolylacetyl)aspartic acid from 3-indolylacetic acid[5]. On the other hand, a distinct spot (R_F 0·04) which has not yet been identified was obtained from 3-indolecarboxylic acid (see Fig. 2).

On the basis of β-oxidation, the propionic, valeric and heptanoic acids ($n = 2$, 4 and 6) would be expected to yield 3-indolecarboxylic acid ($n = 0$) as end product. Though all homologues yielded this acid when metabolized for prolonged periods, no evidence was obtained for the production of the carboxylic acid during the 24-hr. treatment employed in these experiments. During this time-interval, however, the valeric and heptanoic acids were readily converted to the propionic homologue (Fig. 2), and this fact must be considered in relation to the high growth-regulating activity of these three compounds. Such activity cannot be ascribed to the formation from these substances of 3-indolylacetic acid, as no trace of this acid was ever detected on chromatograms of the metabolized propionic, valeric and heptanoic acids. Furthermore, as reported above, substantial quantities of the propionic homologue remained unchanged in metabolism experiments and no other substance showing growth-promoting activity was detected on the chromatograms. All these results strongly suggest that the β-(3-indolyl)propionic acid molecule, like that of 3-indolylacetic acid, can act as a plant growth-regulating substance *per se*. While the propionic acid side-chain ($-CH_2CH_2COOH$) is usually considered susceptible to β-oxidation within plant tissues, it is apparent from other results[3,6] that when this side-chain is attached to certain ring systems the rate of its oxidative degradation is much slower than that of the analogous valeric and heptanoic acids. With such ring structures, it is possible that steric or electronic factors or both might hinder the reactions concerned in the β-oxidation process, especially in the case of those acids where the ring is separated by only a short chain from the carboxyl group. β-(3-Indolyl)propionic acid would appear to be a compound of this type since the side-chain is not readily degraded in pea stem or wheat coleoptile tissues (Fig. 2). Such a hindrance of side-chain degradation would not be expected to occur, however, in those acids where the ring system is well removed from the carboxyl group. This is well illustrated by the rapid conversion of δ-(3-indolyl)-valeric and ζ-(3-indolyl)heptanoic acids to β-(3-indolyl)propionic acid in wheat and pea tissues (Fig. 2).

It is of interest that in β-(3-indolyl)propionic acid (I), the carboxyl group is two atoms removed from the indole ring. The position of this group relative to the ring is thus analogous to that in highly active phenoxyacetic acids such as 2 : 4-dichlorophenoxy-acetic acid (II) :

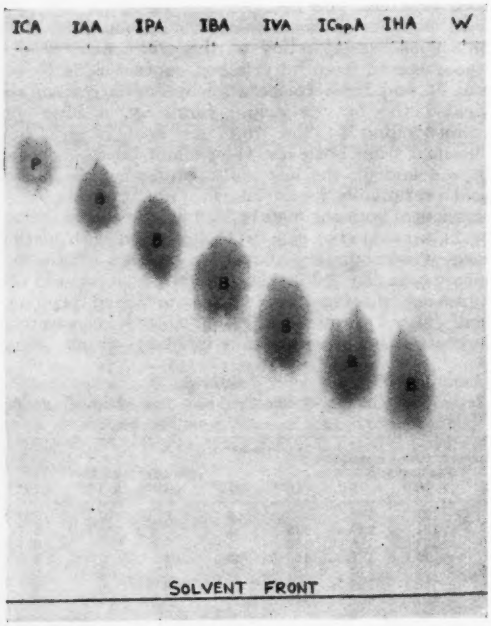


Fig. 1. Chromatogram of 3-substituted indole acids sprayed with Ehrlich reagent. Left to right: carboxylic, acetic, propionic, butyric, valeric, caproic and heptanoic acids and water control. Spot colours indicated by *P* (pink) and *B* (blue)

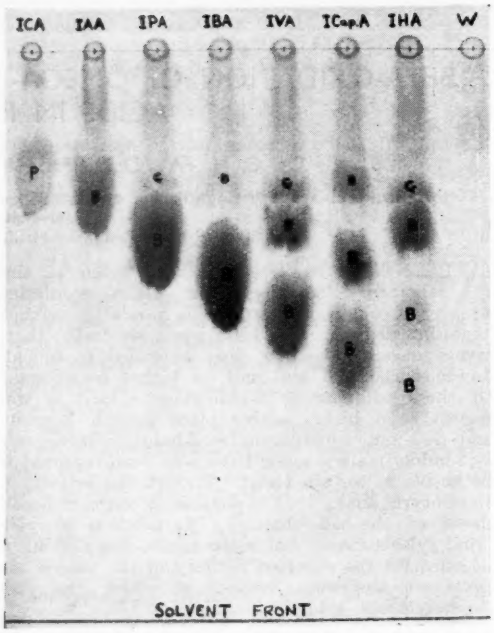
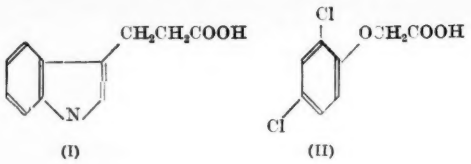


Fig. 2. Chromatogram of same indole acids as in Fig. 1 after their metabolism within wheat tissues. Spot colours (Ehrlich reagent) indicated by *P* (pink), *B* (blue) and *G* (green)



(I) (II)

With appropriate ring systems, therefore, it would seem that plant growth-regulating activity can be associated with the —CH_2CH_2COOH side-chain provided this possesses adequate stability against β-oxidation within the plant.

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MECHANISMS OF FORMATION OF STEREOISOMERS OF 2,3-BUTANEDIOL DURING MICROBIAL FERMENTATION OF SUGARS

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ALL three isomers of 2,3-butanediol [(L+), D(−) and *meso*] are formed as end-products of the fermentation of sugars by various micro-organisms[1]. The mechanisms concerned with the production of these isomers have not as yet been completely elucidated. The present work is a study of the reactions in several bacteria leading to the formation of different stereoisomers of 2,3-butanediol.

The specific rotations of 2,3-butanediols, isolated from culture media containing glucose after the fermentative growth of the organisms used in this study, are shown in Table 1. During these fermentations pyruvate, formed from glucose, is largely converted to lævorotatory acetoin. Acetoin serves as a hydrogen acceptor, being reduced to 2,3-butanediol as outlined in Fig. 1. Acetone-dried cell preparations or cell-free extracts were used to convert pyruvate to acetoin and the optical rotation of the latter compound was determined in each case (Table 1). Since all samples of acetoin were lævorotatory, the mode of reduction of acetoin to 2,3-butanediol cannot be the same for all the micro-organisms and still yield different isomers of 2,3-butanediol.

The steric specificities of the 2,3-butanediol dehydrogenases were determined by oxidizing *meso*-2,3-butanediol in the presence of oxygen, methylene blue, diphosphopyridine nucleotide and hydroxylamine according to Aubert and Gavard[3]. For each organism the acetoin produced was liberated from its oxime with nitrous acid[4] and the optical rotation determined (Table 1). Cleavage of the acetoin oxime has been shown to result in some racemization[4]. It can be seen that the dehydrogenase from *Bacillus polymyxa* oxidized the hydroxyl group in the (−) configuration [(−) dehydrogenase] yielding dextrorotatory acetoin, while the corresponding enzyme from *Aerobacter aerogenes* attacked the hydroxyl group in the (+) configuration [(+) dehydrogenase] yielding lævorotatory acetoin as illustrated in Fig. 2. It is thus possible to explain the formation of the D(−) isomer of 2,3-butanediol from glucose by *B. polymyxa* since the carbonyl group of lævorotatory acetoin, the immediate precursor, is reduced by the (−) dehydrogenase to a hydroxyl group in the (−) configuration (Fig. 1). Similarly, *A. aerogenes* forms 2,3-butanediol which is predominantly the *meso*-isomer since the carbonyl group of lævorotatory acetoin, formed from glucose, is reduced by the (+) dehydrogenase to a hydroxyl group in the (+) configuration (Fig. 1).

Pseudomonas hydrophila oxidized *meso*-2,3-butanediol to lævorotatory acetoin, as did *A. aerogenes*, and therefore contains a (+) dehydrogenase (Table 1). Acetoin formed from pyruvate by *Ps. hydrophila* had a lower specific rotation (− 34°) than did acetoin formed by *A. aerogenes* (− 94°). The lowered rotation of acetoin from *Ps. hydrophila* has been shown to be due to the presence in these cells of an acetoin racemase, since incubation of optically active acetoin with this preparation resulted in a considerable decrease in specific rotation of the acetoin recovered at the end of the experiment. The high specific rotation of acetoin obtained by the oxidation of *meso*-2,3-butanediol (Table 1) with *Ps. hydrophila* may be accounted for by the fact that acetoin was trapped as the oxime in this experiment and was probably not available as a substrate for the racemase. The presence of acetoin racemase in *Ps. hydrophila* accounts for the production of a small amount of L(+)-2,3-butanediol during the fermentation of glucose. Lævorotatory acetoin, the isomer of this

Table 1

Organism	Specific rotation of 2,3-butanediol formed from glucose (deg.)	Specific rotation of acetoin formed from pyruvate (deg.)	Specific rotation of acetoin formed by oxidation of *meso*-2,3-butanediol (deg.)
B. polymyxa	− 10·6*	− 96	+ 73·5
A. aerogenes	+ 0·8 to + 1·8†	− 94	− 73·0
Ps. hydrophila	+ 0·94	− 34	− 70·5
B. subtilis	− 5·7	− 78	− 23·5

* The specific rotation of 2,3-butanediol is a function of the amount of water in the sample measured[2]. Values as high as − 13·3° have been reported for the anhydrous D(−) isomer obtained from *B. polymyxa* fermentations which was shown to be at least 98 per cent pure (ref. 1).

† Values taken from ref. 1.

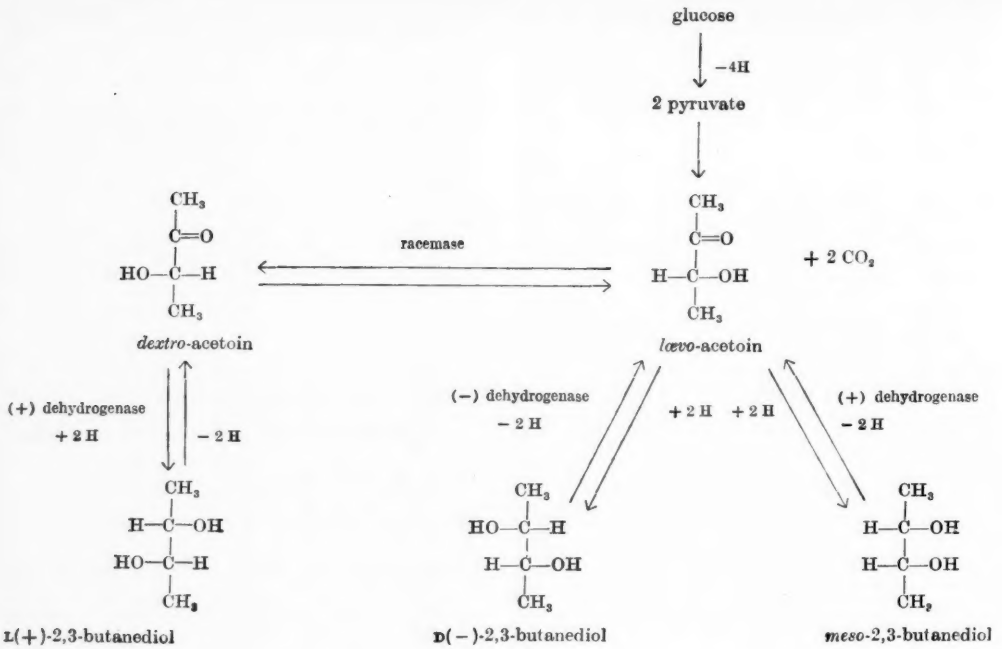

Fig. 1

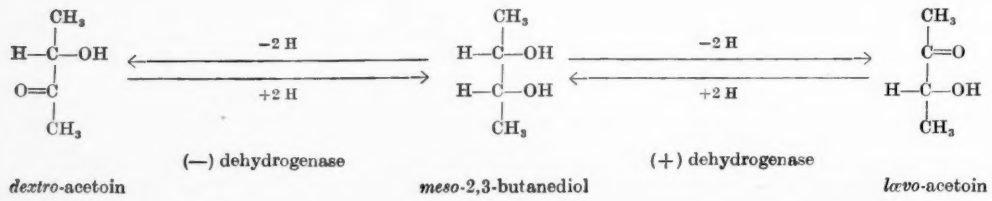

Fig. 2

compound produced from glucose by *Ps. hydrophila*, is reduced to *meso*-2,3-butanediol in the same manner as described above for *A. aerogenes*. The small quantity of dextrorotatory acetoin formed by the action of acetoin racemase is reduced by the same (+) dehydrogenase to L(+)-2,3-butanediol as shown in Fig. 1. The reported formation of some L(+)-2,3-butanediol by various strains of *A. aerogenes* may be due to the presence of acetoin racemase in these species. We have been unable to demonstrate such an enzyme in the *A. aerogenes* preparation studied in this laboratory.

Acetoin produced from pyruvate by *Bacillus subtilis* had a somewhat lower specific rotation than that from *B. polymyxa* and *A. aerogenes* (Table 1). It is possible that there may have been a weak acetoin racemase in the *B. subtilis* preparation. The fact that oxidation of *meso*-2,3-butanediol by *B. subtilis* resulted in the formation of acetoin having a low specific rotation (− 23·5°) was explained by demonstrating that this organism contained a mixture of the (+) dehydrogenase and the (−) dehydrogenase. A crude enzyme preparation from *B. subtilis* could oxidize both D(−)-2,3-butanediol and *meso*-2,3-butanediol. When this preparation was aged at 4° C. for six days it was still active in oxidizing *meso*-2,3-butanediol [(+) dehydrogenase] but showed no activity in oxidizing D(−)-2,3-butanediol [(−) dehydrogenase]. Both enzymes were active after being kept in the frozen state for the same length of time. This finding makes it possible to explain the specific rotation of 2,3-butanediol obtained after fermentation of glucose by *B. subtilis* (Table 1). Lævorotatory acetoin, formed from glucose, is in part reduced by the (−) dehydrogenase to D(−)-2,3-butanediol and in part reduced by the (+) dehydrogenase to *meso*-2,3-butanediol (Fig. 1). A more detailed report of this work will appear elsewhere.

One of us (M. B. T.) is indebted to the Division of Basic Health Sciences of Emory University for a research fellowship during the tenure of which much of the work was done. This investigation was aided by a grant from the National Science Foundation, and was initiated in the Department of Bacteriology, University of Illinois, Urbana, Illinois.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Radioactivity of Plant Material collected after the Accident at Windscale No. 1 Pile

At the time of the Windscale accident on October 10, 1957, it was considered that it would be of botanical interest to determine the amount of radioactivity occurring in vegetation in the vicinity of the reactor, and accordingly a small-scale investigation was carried out by us. Since no precise figures have been issued officially, the present observations will provide an indication of the level and nature of the activity present in the vegetation.

Eight days after the release of activity, the aerial parts of plants were collected from several sites south of the reactor. Further samples were collected from both north and south of the reactor on November 4 (25 days after the accident). The plant material was dried, powdered and transferred in the form of a slurry on to steel planchets 1·5 cm. in diameter. It was not possible by this method of sampling to differentiate between activity due to surface deposition and that translocated through the plant. However, most of the material, particularly the bracken (*Pteridium aquilinum*), was not in an actively growing state, and it was improbable that much translocation would occur. The planchets were counted at a distance of 1·5 cm. from the end window of a Mullard *MX* 123 Geiger–Müller tube. Three counts of 3 min. duration were made each time the sample was counted, and the mean count per minute per gram dry-weight of material was determined (see Table 1). In this counting system, approximately 65,000 counts per min. corresponded to 1 μc. of radioactivity. The allowance that was made for an average self-absorption factor, the solid angle of the counter and the absorption due to the intervening airspace and the counter window, was subject to an error of × 2.

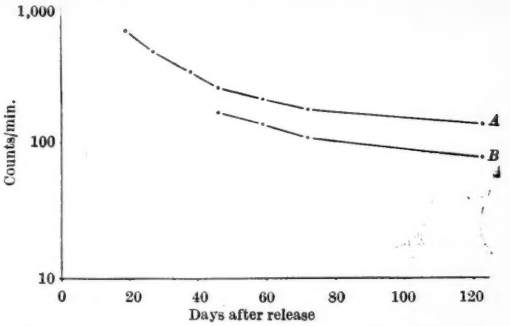

Fig. 1. *A*, Sample taken after 8 days; *b*, sample taken after 25 days

Fluctuation in activity occurred at sites equidistant from the reactor, probably due to local meteorological conditions, but in general the activity decreased with increasing distance south of the reactor. Samples collected on November 4 from the area north-west of the reactor showed considerably less activity than samples of the same species from south of the reactor collected on the same day. At a given distance from the reactor, activity of the grass samples (*Agropyron repens*) was consistently less than that of the other species collected; this difference may be interpreted as a function of the plant habit. The species with an activity higher than grass were taller and more widely spaced and would offer a greater effective surface area per unit weight for the deposition of material from the air.

Fig. 1 shows the decay curves of two samples of equal weight of stinging nettle (*Urtica dioica*) collected eight and twenty-five days after the release. The lower specific activity of the second sample (curve *B*) can be attributed to the removal of surface activity by rain in the period between the collection of the two samples. This lower specific activity of the second sample also suggests that the accumulation of radioactive material is a surface phenomenon and is not due to root absorption and translocation.

With regard to the nature of the radioactive material present in the samples, it is evident, from a

Table 1. Site, Sample Weight and Mean Counts per Minute per Gram Dry-weight of Samples of Plant Material Collected 8 and 25 Days after the Windscale Accident

Approximately 65,000 counts per minute corresponds to 1 μc. of radioactivity. The distance of the site of collection from Windscale is given to the nearest quarter-mile

Samples 1–12 collected on October 18; samples 13–24 collected on November 4

No.	Material	Site	Sample weight (mgm.)	Mean counts/min. for various No. of days after the accident						
				19	27	38	46	59	72	123
1	*Pteridium aquilinum*	S. 60° E. 8 m.	77·3	1,436	1,022	543	388	310	259	168
2	*Agropyron repens*	S. 61° E. 6 m.	97·1	103	113	113	93	72	—	—
3	*Agropyron repens*	S.E. ½ m.	85·8	443	256	210	163	82	—	—
4	*Pteridium aquilinum*	S.E. ½ m.	119·4	527	327	176	159	84	67	—
5	*Agropyron repens*	S. ¼ m.	77·6	837	528	348	180	129	—	—
6	*Urtica dioica*	S. ¼ m.	135·7	7,222	5,527	3,861	3,161	2,808	2,329	1,489
7	*Agropyron repens*	S. 3 m.	139·7	1,625	1,052	615	444	372	322	229
8	*Agropyron repens*	S. 32° E. 4½ m.	107·8	454	353	176	148	74	—	—
9	*Agropyron repens*	S. 34° E. 8 m.	91·8	207	218	174	131	87	—	—
10	*Agropyron repens*	S. 22° E. 15½ m.	91·2	537	417	208	218	132	77	—
11	*Agropyron repens*	S. 38° E. 18½ m.	80·7	867	570	211	87	50	—	—
12	*Agropyron repens*	Manchester	93·3	96	96	64	54	75	—	—
13	Umbel. sp. unknown	N.W. ¼ m.	94·3	—	—	—	265	159	117	42
14	*Urtica dioica*	N.W. ¼ m.	94·4	—	—	—	180	41	82	—
15	*Rubus* sp.	N.W. ¼ m.	123·8	—	—	—	113	64	64	—
16	*Agropyron repens*	N.W. ¼ m.	63·3	—	—	—	189	63	63	—
17	*Crataegus monogyna*	N.W. ¼ m.	99·4	—	—	—	186	50	60	—
18	*Rumex* sp.	N.W. ¼ m.	91·6	—	—	—	108	66	55	—
19	Umbel. sp. unknown	S. ¼ m.	77·3	—	—	—	2,484	1,643	1,514	1,242
20	*Urtica dioica*	S. ¼ m.	92·3	—	—	—	1,787	1,484	1,148	813
21	*Rubus* sp.	S. ¼ m.	85·2	—	—	—	1,127	775	622	399
22	*Agropyron repens*	S. ¼ m.	80·9	—	—	—	865	618	544	420
23	*Crataegus monogyna*	S. ¼ m.	88·5	—	—	—	1,514	1,130	768	418
24	*Rumex* sp.	S. ¼ m.	81·3	—	—	—	1,918	1,550	960	627

consideration of the rates of decay, that the activity present is not solely due to iodine-131. The change of gradient in curve *A* in the graph indicates that isotopes with half-lives considerably in excess of eight days are present. An anomalously high count was obtained in a sample of nettles collected on the earlier date a quarter of a mile south of the reactor. Partial covering of the planchet with lead foil led to the discovery that the high activity occurred at only one point. By stepwise removal of the less active parts of the sample, it was possible to localize a source of high activity (7,704 counts/min. 19 days after the release) in less than a milligram of material. This source was found to be a β-emitter of 1·45 MeV. with a half-life of 54 days; these values are in close agreement with the values for strontium-89 (1·46 MeV., 53 days). However, the average half-life of the non-iodine fraction of the nettle sample shown in curve *A*, between 72 and 123 days, is 83 days, suggesting that strontium-89 is not the only other isotope present.

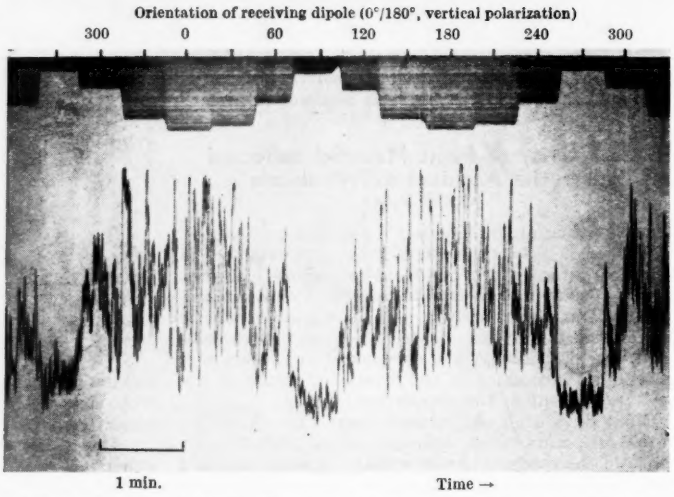

Fig. 1. Signal level of lunar radio reflexion as a function of time and orientation of receiving dipole

Samples collected a quarter of a mile (Nos. 6, 19–24) and three miles (No. 7) south of the reactor show relatively large amounts of non-iodine activity. For samples 6 and 7, it was calculated that 19 days after the release half the observed counts of the nettle (6) and a third of the grass (7) were due to isotopes other than iodine-131. At the time of release these fractions would be one-fifth and one-tenth, respectively. The decrease in non-iodine activity with increasing distance from the reactor, as illustrated by these two samples, would be expected if the material responsible was particulate. Activity of iodine-131 in samples 6 and 7 immediately after the release was calculated to be 0·25 and 0·08 μc./gm. dry weight of material, respectively.

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Measurement of the Ionospheric Faraday Effect by Radio Waves reflected from the Moon

Rotation of the plane of polarization (the Faraday effect) of radio echoes from the Moon has been used by Browne, Evans, Hargreaves and Murray[1] and by Evans[2] to determine the total electron content of the ionosphere. The method is based upon the fact that the plane of polarization of a linearly polarized wave during its double passage through the ionosphere is rotated by an amount:

$$\varphi = 4{\cdot}72 \times 10^4 f^{-2} B \cos\theta \sec\delta \int_{H_1}^{H_2} N \, dh \text{ (radians)}$$

where f is the frequency of the transmitted wave in c./s., B is the Earth's magnetic field in gauss at ionospheric levels, θ is the angle between the direction of propagation and the Earth's field, δ is the zenith angle of the path, N is the electron density per cm.[3] and dh is an element of height in cm. The limits of integration correspond to the region in which the ionization is large enough to make an appreciable contribution to the rotation. The assumption is made that B is constant throughout this region and has a value of 0·5 gauss. The value of the constant in the above equation published by Browne, *et al.*[1] appears to be in error by a factor of two, although the value given at a later date by Evans[2] is correct. The reason for the error is that the angular rotation was taken to be equal to the phase difference between the ordinary and extraordinary rays. The parameter of interest, however, is the displacement from its initial position of the resultant of two vectors, one of which has rotated clockwise and one counter-clockwise. This resultant is displaced $(\varphi_1 - \varphi_2)/2$ from its initial position, where φ_1 and φ_2 are the absolute values of the rotations of the two component vectors.

To obtain an unambiguous result, two closely spaced frequencies were used by Browne *et al.*[1] and by Evans[2], who determined the angle between the planes of polarization of the two waves. The electron content can also be obtained by using a single frequency sufficiently high (400 Mc./s. or above) so that the quantity φ does not exceed π radians at the time of minimum electron density. Measurements described below were made at a single frequency of 151·11 Mc./s. and do not, therefore, give the absolute value of the total electron content, but do provide a relatively sensitive measure of the rate of change of this quantity.

The equipment consisted of separate transmitter and receiver, the former located at Belmar, N.J., and the latter at Urbana, Ill. The transmitter provided 50 kW. of continuous wave power at 151·11 Mc./s. to a dipole feed located at the focus of a 50-ft. paraboloidal reflector. The receiving antenna consisted of a 28-ft. dish and a dipole that could be continuously rotated in a plane perpendicular to the axis of the paraboloidal reflector. Both antennæ were mounted so as to make it possible to track the Moon from moonrise to moonset.

During the night of January 8–9, 1958, the equipment was operated continuously from 11.30 p.m. until

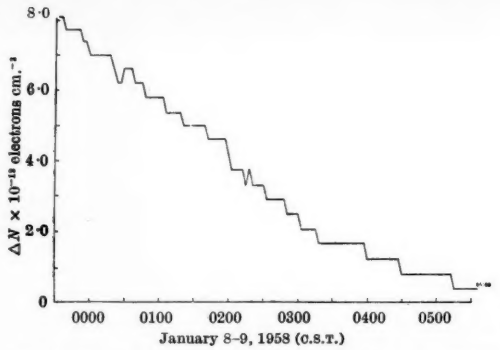

Fig. 2. Time variation of the total electron content of the ionosphere (determined from Faraday-rotation measurements) relative to an arbitrary zero-level

6.00 a.m. Central Standard Time. At 6.00 a.m. operation had to be discontinued because of high noise-levels due to ignition interference from traffic. The receiving antenna was rotated in steps of 30° at 30-sec. intervals, and the antenna orientation was recorded together with the received signal-level. Whenever the dipole was oriented normal to the electric vector of the incoming wave, the recorded signal passed through a minimum. At three-minute intervals (once per 180°) the positions of the signal minima relative to the dipole orientation were determined. Fig. 1 shows a section of the record, and Fig. 2 a plot of ΔN as a function of time, where ΔN is the change in total electron content relative to an arbitrary zero level. ΔN was computed from the following formula:

$$\Delta N = 1{\cdot}933 \times 10^{12}\varphi(\cos\theta \sec\delta + \cos\theta' \sec\delta')^{-1} \text{ electrons cm.}^{-2}$$

where the numerical values of B and f are included in the constant and the primed and unprimed angles refer to values at Belmar, N.J., and Urbana, Ill., respectively. The change in total electron content from 2333 hr. to 0600 hr. (Central Standard Time) is seen to be $7{\cdot}7 \times 10^{13}$ electrons cm.$^{-2}$. This is about 2·2 times the change computed for a parabolic layer using vertical sounding data recorded at the transmitting site.

At a later date we plan to make supplementary measurements on 413 Mc./s. to resolve the ambiguity in φ and thus to obtain absolute values of total electron concentration. We also hope that operating at certain times of low noise-levels will make it possible to obtain results throughout an entire diurnal cycle.

We wish to acknowledge the assistance of Prof. H. D. Webb of the University of Illinois, who operated the receiving equipment, and Mr. Alan S. Gross and his assistants at the U.S. Army Signal Engineering Laboratories, Belmar, N.J., who operated the transmitting equipment. We also wish to thank Mr. Nathan Gordon and Mrs. Mary Tate of the latter organization, who carried out the mathematical computations on the *IBM* 650 computer.

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A Device for visualizing the Pattern of Plane Polarized Light from Blue Sky

THE entomologist studying insect behaviour faces the problem of determining how the environment appears to insects, through their sense organs. The many differences in the sensory apparatus of man and insects represent one reason why it is difficult for us to appreciate fully the insect environment. For example, our own insensitivity to the plane of polarization of light has long kept us from recognizing an aspect of sky light which is of significance in the behaviour of many insects and other arthropods. Although it has long been known that daylight from most areas of blue sky is partly plane polarized, in a pattern which bears a definite relationship to the Sun's position, only within the past decade has it become established that arthropod eyes are sensitive to changes in the polarization of light. It has been found, also, that a variety of these animals refer to the plane of polarization of light from blue sky in their orientation reactions[1].

The direction of certain flights of the beetle, *Melolontha*, appears to be influenced by the pattern of polarized sky light[2]. As a result of considering the possibility of a similar mechanism in the flight orientation of bark and ambrosia beetles (Scolytidae) at times, a method by which the human eye can 'see' the polarization pattern in much of the blue sky was devised. It enables the human eye to detect aspects of light which are apparently perceived by arthropod eyes, namely, the plane and, to a lesser extent, the relative amount of polarized light. This is accomplished by observing the sky through a rotating 'Polaroid'-covered slit. Cialdea[3] used a similar method, but a photoelectric cell was employed as the photoreceptive unit. When observing a polarized light source through such a slit there is continued repetition, in respective parts of the visual field, of the dark and light effects which occur when one observes the source through a sheet of 'Polaroid' while the latter is slowly rotated. With slits ranging from a few up to around 45 degrees in arc and rotating six times a second or faster, a patch of blue sky with a high percentage of polarized light appears as in Fig. 1. The relationship of such a pattern to the plane of polarization of the light depends on the polarizing axis of the 'Polaroid' covering the slit. With the axis at 90 degrees to the slit, the darker zones indicate the plane of polarization of the light.

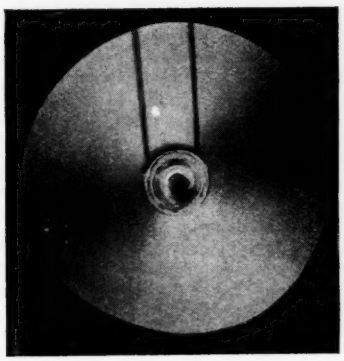

Fig. 1. Photograph, taken through rotating 'Polaroid'-covered slit, of blue sky near point of maximum polarization, showing nature of pattern seen with the eye

A working model has been constructed as follows: a 'Polaroid' and a black paper disk, the latter with a slit in it, are held between two transparent plastic disks and all these parts are mounted together on a shaft so they can rotate between two fixed sheets of plastic. These in turn are mounted at the end of a black sheet-metal viewing cone. Rotation of the slit is effected by a small battery-operated motor through a rubber-band drive.

As one scans the blue sky with this viewer the plane of polarization of light can be detected over much of the sky, and differences in percentage of polarized light from different directions are apparent from the amount of contrast between the light and darker zones of the visual field. What one sees is dependent on integration of light from the rotating slit by the eye, and there are undoubtedly several factors which influence detection of plane of polarization when percentage of polarized light is small. When it is large, as in blue sky at or near the zenith when the sun is rising or setting, quite accurate determinations of polarization plane are undoubtedly possible, so that the device could be used as a sky compass[4]. A logical modification would be to use a rotating hemisphere instead of a disk, so that the whole sky pattern, not just that in a small section, could be seen at once.

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Thickness Measurement of Epitaxially Grown Films

Many substances are known to grow epitaxially when deposited on suitable single crystal substrates. A review of epitaxial growth has been given by Pashley[1]. The single-crystal film is of importance since its behaviour is easier to interpret than that of a polycrystalline film, in which both crystallite size and orientation are variable. Rock-salt crystal is frequently used as a substrate because the film can be easily removed from its surface by dissolving the underlying crystal. It is essential that the film be removed for study, in order that the strain associated with the epitaxial process be removed by annealing. Measurement of the thickness of such films raises a slight difficulty because a cleaved rock-salt surface, although flat over very small areas, is rarely flat enough to enable the usual multiple-beam fringe methods[2] to be applied directly.

In experiments on iron and nickel films, the thickness has been determined as follows. The film is floated off the rock-salt and is picked up on a glass flat. The flat is stood vertically in a desiccator and allowed to dry. The edge of the film is silvered and Fizeau fringe measurements of the step-height made in the usual way. As shown in Fig. 1, there is some deterioration in the film surface, but this does not prevent accurate measurement of the film thickness. In order to determine whether the procedure gives the thickness correctly, films were prepared on glass flats simultaneously with those on rock-salt. The thicknesses of the films on glass were

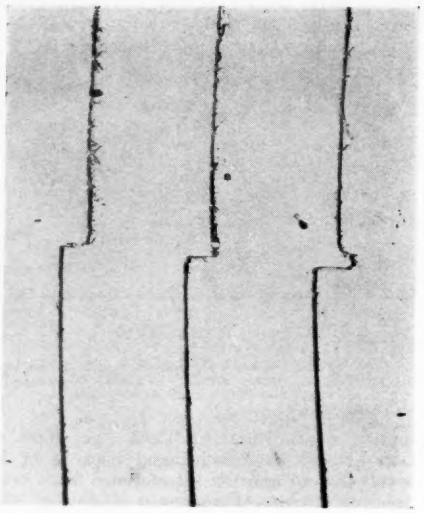

Fig. 1

determined directly by Fizeau fringes and were compared with those of films which had been removed from the rock-salt. Within the accuracy of measurement (±20 A.) over the range of thicknesses used (130–450 A.) the two sets of results agreed.

For these experiments, the films were deposited on glass and rock-salt plates at room temperature. Under this condition the assumption that all the incident molecules condense is justified. This assumption is found not to be valid when the surfaces are maintained at high (400–500° C.) temperatures.

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Molar Sound Velocity of Solids

According to Rama Rao[1] an empirical relationship exists between the temperature coefficients of the velocity of sound (v) in organic liquids and their density ρ:

$$\frac{1}{v}\frac{dv}{dT} = \frac{A}{\rho}\frac{d\rho}{dT} \qquad (1)$$

where A is practically equal to 3 for unassociated compounds.

It follows that the functions $\frac{v^{1/3}}{\rho}$ and $\frac{v^{1/3}M}{\rho}$, the specific and molar sound-velocities respectively, are independent of temperature. The molar sound-velocity can be calculated from atomic increments[2], bond increments[3] or radical increments[4] and can therefore be utilized in structural determinations on organic compounds.

For solid substances, in particular high polymers, A is considerably higher[5] than 3. A theoretical interpretation of this factor can be given starting from the relationship:

$$v^2 = \frac{1}{\beta\rho} \quad (2)$$

where β is the compressibility.

Assuming further that the interaction between the molecules is represented by the potential:

$$U = -\frac{a}{r^n} + \frac{b}{r^m} \quad (3)$$

it appears that A is only a function of n and m:

$$A = \frac{n + m + 1}{6} \quad (4)$$

This equation does not account for the large difference between the values of A for solids and liquids. The cause of this discrepancy is to be sought in the fact that equation (2) holds only for fluids, whereas for solids we have to start from the general relationship:

$$v_l^2 = \frac{3}{\beta\rho} \cdot \frac{1 - \sigma}{1 + \sigma} \quad (5)$$

where v_l is the longitudinal sound-velocity and σ is the Poisson ratio (for liquids σ is $\frac{1}{2}$).

From this it follows that (1) is the special case for liquids of the general relationship:

$$\frac{1}{v_l}\frac{dv_l}{dT} = \frac{A}{\rho}\frac{d\rho}{dT} - \frac{1}{1 - \sigma^2}\frac{d\sigma}{dT} \quad (6)$$

This implies that not $\frac{v^{1/3}M}{\rho}$ but $\frac{v^{1/3}M}{\rho}\left[\frac{1+\sigma}{3(1-\sigma)}\right]^{1/6}$ is an additive function for solids. This corrected molar sound-velocity can be calculated from the same increments as that for liquids.

The values of A for polyethylene calculated from (1) were found to lie between 5 and 9, whereas (6) gives values of 2·9–3·4.

A detailed paper on this subject will be published elsewhere.

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Measurement of Nuclear Magnetic Moments in Atomic Beams

The purpose of this communication is to describe a magnetic resonance experiment which we have performed with three radio-frequency loops situated in the C field of an atomic-beam apparatus, and to propose an application. Apart from the three loops, we used a conventional 'flop-in' arrangement with short A and B magnets. The method to be described allowed the measurement in a short apparatus of transitions for which $\Delta m_J = 0$; such lines are usually unobservable except in machines with long A and B magnets[1]. The atomic beam was potassium-39, for which $J = \frac{1}{2}$ in the ground-level and $I = 3/2$.

The scheme was as follows: the beam passed through the three loops A, C and B in order. Each loop was $\frac{1}{8}$ in. long and was separated from its neighbour by $3\frac{1}{2}$ in. They were all in the gap of the C magnet, which produced a field of about 25 gauss. The polarizer in this apparatus was essentially the magnet A and loop A taken together. Similarly, loop B and magnet B formed the analyser, while loop C was used to excite the transition under investigation. Suppose that in loop A the transition ($F = 2$; $m = -1 \longleftrightarrow -2$) is induced with a transition probability at resonance of a. This transition by itself gives rise to a signal of $2a$ in arbitrary units at the detector. The same line is excited in loop B (by radiation incoherent with that in loop A) with transition probability b: the signal changes to $2a + 2b\ (1 - 2a)$. The change may be of either sign, depending on the relative magnitudes of a and b. The formula shows that when a has the value 0·5, there is no change of signal intensity on turning on loop B, irrespective of the value of b. This affords an absolute method of determining transition probabilities in terms of signal intensity. It is a special case of the so-called 'flop-out on flop-in' technique[2]. If now the transition ($F = 2$; $m = 0 \longleftrightarrow -1$) is excited in loop C with transition probability c, there is a further change in the signal, which becomes $2a + 2b(1 - 2a) + c(2ab)$. The most favourable case is that when a, b and c are each a maximum. In our experiment the observed intensities were: loop A on alone, 1·8 units; loop B on alone, 1·8 units; loops A and B on, 0·36 units; loops A, B and C on, 1·8 units. These intensities are consistent with the values $a = b = c = 0{\cdot}9$. This high value may be due to the beam having only a limited range of velocities; such a situation may be expected if, as in our experiment, the focusing conditions are not properly fulfilled. Moreover, the transition probability at resonance calculated in this way was consistent with the absolute determination mentioned above.

The field at the C loop was measured with the A and B loops off in terms of the transition ($F = 2$; $m = -1 \longleftrightarrow -2$) in the C loop. The frequency of the line ($F = 2$; $m = 0 \longleftrightarrow -1$) agreed with the value expected at the measured field; and, as a check, it was compared with the value which can be deduced from the double-quantum jump ($F = 2$; $m = 0 \longleftrightarrow -2$). There was no evidence that there were any frequency shifts due to interaction between the radio-frequency loops.

We carried out this experiment to demonstrate a way of measuring nuclear magnetic moments in an apparatus with short A and B magnets. If loop A is placed in the space, where the magnetic field is low, between the A magnet and the C magnet and loop B is between the C and B magnets while loop C is in a high field, then one should be able to induce in the C loop the transition ($m_J = \frac{1}{2}$; $m = 0 \longleftrightarrow -1$). Thus the value of the nuclear magnetic moment could be deduced from the high-field transition, for which $\Delta m_J = 0$, $\Delta m_I = \pm 1$, in the usual way[3]. One might arrange for purposes of stability that the transition excited in loops A and B be one that is independent of field to first order, though we did not find this precaution necessary in our low-field experiment. Also, one might introduce small iron magnets in the regions of the A and B loops in case the stray fields in these positions have inconvenient values.

The method should give the same information as that obtained from a long apparatus, but with the advantage inherent in short machines, namely, a large gain in beam intensity. Thus it should be applicable in cases where this consideration is important: in measuring, for example, isotopes which are radioactive or of low abundance, and atoms which can only be detected with low efficiency.

We are engaged in measuring the hyperfine structure in the ground-level of europium, and this method will be used to obtain an accurate ratio of the nuclear magnetic moments in the two stable isotopes in order to find a Bohr–Weisskopf anomaly. As with other rare earths, the moments have not been measured by nuclear resonance in a solid or liquid sample.

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Change of Length during Transformation of Iron under Stress

It is well known[1] that various metallic materials are mechanically weak while being transformed into another allotropic modification. We measured the change of length of specimens of pure iron[2] while the metal, kept under tensile stress, was heated through the transformation temperature at 910° C. In Fig. 1 the change of length for fine-grained iron has been plotted for one α–γ transformation, one γ–α transformation and for a complete α–γ–α cycle as a function of stress. The resultant strain for the complete cycle gives a straight line through the origin. The fine-grained material for these experiments was obtained by loading the iron with a small amount (0·008 per cent by weight) of nitrogen[3]. All measurements were made *in vacuo*. An iron–carbon alloy containing 0·2 per cent by weight of carbon behaves in essentially the same way when given a temperature cycle through the two-phase field α + γ.

The rates of heating and cooling were varied, in one case between 1 and 10 deg. C. per min. This did not affect the values of the elongations. These therefore do not represent some kind of creep. A similar conclusion for the transformation of cobalt has been reported in a recent investigation[4].

A clear-cut explanation of the mechanical behaviour during phase transformation cannot be offered as yet. Experiments on coarse-grained iron, however, are illuminating. They show that the volume change during transformation is intimately connected with the observed phenomena. In the absence of impurities, coarse-grained α-iron forms during the γ–α transformation[3]. Probably large γ-grains are also created in the reverse process. During transformation of the coarse-grained specimens the length does not always change monotonously. The values of the elongation are not really reproducible. They do not define lines, as in Fig. 1, but fields as in Fig. 2. In Fig. 1 the change of length during a one-way transformation, for vanishing external stresses, is equal to one-third of the relative volume change as measured by X-ray diffraction[5]. In Fig. 2 all values between $(\Delta V/V)/3$ and $\Delta V/V$ are found. In the range of stresses below 600 gm./mm.², $|\Delta V/V|$ is the maximum change of length obtainable.

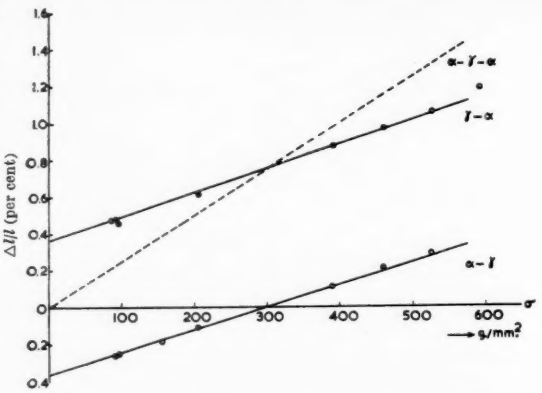

Fig. 1. Change of length due to phase transformation under stress of specimens of pure iron containing 0·008 per cent of nitrogen by weight. Diameter of specimens: 2–2·5 mm. The cross-section contained about 100 crystals of arbitrary orientation. Pressure about 10^{-5} mm. mercury

In the γ–α transformation, during which the volume change and the external stress both tend to elongate the specimen, we see that $\Delta l/l$ is nearly $\Delta V/V$ for a steep temperature gradient (5 deg. C./cm. as measured on the sample). This behaviour agrees with observations on unstressed specimens[6].

A rough description of the experimental facts can be given if a tendency for the mean macroscopic dilatation to be zero along the phase boundary is assumed. This is a rigorous condition for diffusionless transformations[7,8].

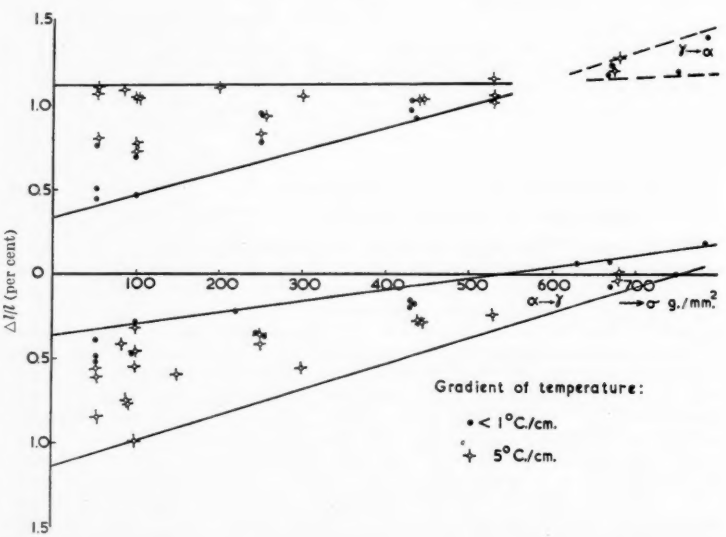

Fig. 2. Change of length due to phase transformation under stress of coarse-grained specimens of pure iron. Flat (cross-section: 1 mm. × 3 mm.) and cylindrical (diameter: 2–2·5 mm.) specimens containing a few crystals on the cross-section. Pressure about 10^{-5} mm. mercury. $\Delta V/V$: 1·06 per cent (ref. 5)

Consider first transformations in the absence of external stresses. If pure coarse-grained iron is transformed in a steep temperature gradient along the axis of the specimen, the phase boundary may be regarded as plane, and as normal to this axis. Then the assumption leads to $\Delta l/l = \Delta V/V$. If on the other hand there is no temperature gradient along the axis, the phase boundary will not necessarily be normal to it and $|\Delta l/l| \ll |\Delta V/V|$. In a two-phase alloy (iron, 0·008 per cent nitrogen by weight; iron, 0·2 per cent carbon by weight) a growing crystal can form a closed boundary within the matrix. Displacement of this phase boundary causes slip in the matrix in arbitrary directions, leading to $\Delta l/l = (\Delta V/V)/3$.

It is to be expected that the effect of external stresses will be different where they favour the change of length due to the change in volume (γ–α) from the case where they oppose this change of length (α–γ). This is evident from Fig. 2, where in the presence of stresses $(\Delta l/l)_{max.} = (\Delta V/V)$ for the γ–α transition, but $|(\Delta l/l)_{max.}| < |(\Delta V/V)|$ for the α–γ transition. In the transformation of the two-phase alloys an external stress removes the equivalence of the slip systems, which in the matrix are activated by the change of volume. Those slip systems which allow a decrease of the mechanical potential energy are favoured.

A full account of these results will be published elsewhere. This work is part of the research programme of the Research Group Metals F.O.M.–T.N.O., sponsored by Z.W.O.

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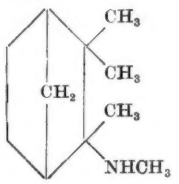
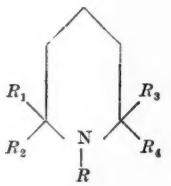
Polyalkylpiperidines : a New Series of Ganglion-blocking Agents

IN 1956 Stone, Torchiana, Navarro and Beyer[1] discovered that powerful ganglion-blocking properties, hitherto demonstrated only in quaternary bases, were possessed by the secondary amine 3-methylamino*iso*camphane (mecamylamine); nothing comparable has since been described. A study of a variety of secondary and tertiary bases in which the nitrogen atom is closely surrounded by alkyl groups has now shown that many polyalkylpiperidines (U.K. Patent Applications Nos. 4905/57, 4906/57 and 4907/57) are highly active as ganglion-blocking and hypotensive agents. The most promising of a large series examined were 1 : 2 : 2 : 6 : 6-pentamethylpiperidine (I; $R = R_1 = R_2 = R_3 = R_4 =$ Me) and 1-ethyl-2 : 2 : 6 : 6-tetramethylpiperidine (I; $R =$ Et; $R_1 = R_2 = R_3 = R_4 =$ Me). These and related compounds were tested intravenously in the cat, anaesthetized with chloralose, for their ability to block preganglionic stimulation of the nictitating membrane. By this test, the pentamethyl compound was about 2·5 and the ethyl tetramethyl compound about 3·0 times as potent as mecamylamine and the effects of all three drugs were of similar duration, a single dose of 0·2 mgm./kgm. of the ethyl compound having a perceptible effect for approximately two hours. Both compounds also block the pressor response to phenyldimethylpiperazinium, carotid occlusion, and efferent splanchnic stimulation, and, in the atropinized cat, to acetyl choline, all these actions being impressive after doses of 0·1–0·2 mgm./kgm. of either drug. The drugs block the contraction of the guinea pig ileum, elicited *in vitro* by phenyldimethylpiperazinium, reduce intestinal motility *in vivo* as judged by rate of excretion of fæces by mice, and reduce the rate of spontaneous secretion of gastric juice in the rat. By the last test 1 : 2 : 2 : 6 : 6-pentamethylpiperidine is twice, and 1-ethyl-2 : 2 : 6 : 6-tetramethylpiperidine three times as potent as mecamylamine when all three drugs are given subcutaneously.



Mecamylamine



(I)

Both 1 : 2 : 2 : 6 : 6-pentamethylpiperidine and 1-ethyl-2 : 2 : 6 : 6-tetramethylpiperidine are ineffective at a bath concentration of 0·03 mgm./ml. in blocking contraction of guinea pig ileum elicited by acetyl choline, histamine or 5-hydroxytryptamine and are only feebly effective at 0·03 mgm./ml. in blocking the contraction of the rat seminal vesicle elicited by noradrenaline or adrenaline. They fail to block postganglionic stimulation of the nictitating membrane. These findings establish a ganglionic site of action, though some other actions have been demonstrated, notably an ability, in doses of 10–25 mgm./kgm. intravenously, to block indirect stimulation of the cat gastrocnemius muscle, and in concentrations of 0·01 mgm./ml. to slow the rate, reduce the amplitude of beat and reduce the coronary flow of the isolated rabbit heart perfused with Ringer–Locke solution. Central nervous actions are suspected from their ability, in toxic doses, to cause tremor. These three types of side-effect are also displayed by mecamylamine when given in similar doses to 1 : 2 : 2 : 6 : 6-pentamethylpiperidine and 1-ethyl-2 : 2 : 6 : 6-tetramethylpiperidine. The nature of their action on ganglia is being studied, particularly in relation to the claim by Zaimis and her colleagues[2] that mecamylamine differs in its action on ganglia from hexamethonium. We have observed after the intravenous administration of mecamylamine, 1 : 2 : 2 : 6 : 6-pentamethylpiperidine or 1-ethyl-2 : 2 : 6 : 6-tetramethylpiperidine the same very slow onset of action and protracted action, and have also observed that the quaternary compound 1 : 1 : 2 : 2 : 6 : 6-hexamethylpiperidinium iodide has a ganglion-blocking action which is extremely rapid in onset and brief in duration. It seems possible therefore that the ganglionic action of the quaternary compound is extracellular and that of 1 : 2 : 2 : 6 : 6-pentamethyl

piperidine and 1-ethyl-2 : 2 : 6 : 6-tetramethylpiperidine intracellular.

The toxicities of the new drugs for mice is shown in Table 1 in comparison with that of mecamylamine (doses are as free bases: each was given as the hydrochloride).

Table 1. *LD*50 for administration by various routes

	Intravenous	Oral	Intraperitoneal
Mecamylamine	25	110	40
1 : 2 : 2 : 6 : 6-Pentamethylpiperidine	80	700	175
1-Ethyl-2 : 2 : 6 : 6-tetramethylpiperidine	65	375	100

Though considerably more active than mecamylamine, 1 : 2 : 2 : 6 : 6-pentamethylpiperidine and 1-ethyl-2 : 2 : 6 : 6-tetramethylpiperidine are less toxic. Their excellent absorption after oral administration is inferred from the low ratio of oral to intravenous lethal dose and from the effects in mice, rats and dogs of oral doses of 1–50 mgm./kgm.

A full account of this work will be presented elsewhere.

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Free Radical produced in the Reaction of Metmyoglobin with Hydrogen Peroxide

In a previous communication[1], it was reported that a free radical is formed during the action of hydrogen peroxide on methæmoglobin. As its g-value approximated to that of a free electron, this result was interpreted in terms of electron removal from the π-orbitals of the porphyrin ring, by analogy with the reactions occurring during the oxidation of porphyrins and phthalocyanines[2]. This explanation, involving the postulate of little interaction between unpaired electron and central iron atom, conflicted with the results of titration studies[3], and the evidence from paramagnetic susceptibility[4].

This free radical was therefore reinvestigated using sperm whale metmyoglobin solutions of known concentration. The solutions were placed in ¼-in. diameter tubes and inserted directly into an H_{014} 3 cm. wave-length cavity resonator. The samples and cavity were cooled to 90° K. to remove the high dielectric loss associated with water. High-frequency modulation and phase-sensitive detection were employed so that free-radical concentrations of 10^{-4} M gave a signal-to-noise ratio of about 10 : 1. In each case the formation and destruction of peroxide compound was followed optically, using a bench microspectroscope.

After adding hydrogen peroxide to solutions of metmyoglobin in pH 8·0 borate buffer, a free radical was produced, giving an electron-spin resonance signal at a g value of $2{\cdot}0036 \pm 0{\cdot}0006$, with a width at half power of 11 gauss. A systematic series of experiments was then undertaken to determine the exact conditions under which this free radical was formed. The results obtained indicate a close connexion between free radical and metmyoglobin peroxide compound, but show that the free radical cannot be identified with the peroxide compound itself. This evidence can be summarized as follows: (1) The formation of free radical is specific for the metmyoglobin peroxide reaction; it does not occur in model systems such as serum albumin – iron – hydrogen peroxide or metmyoglobin cyanide – iron – hydrogen peroxide; (2) the removal of excess peroxide by catalase does not affect the free radical; (3) the amount of free radical is proportional to the initial concentration of metmyoglobin, under comparable conditions; (4) the free radical is destroyed by substances reducing the peroxide compound (ferrocyanide, nitrite, iodide, p-cresol); (5) the calculated concentration of free radical in the most favourable case was only 9 per cent of the peroxide compound; (6) its concentration varied widely under conditions in which the amount of peroxide compound remained approximately constant. Thus increase of pH from 6 to 10 decreased the free-radical concentration by 80 per cent, while the peroxide compound was formed equally well at these pH values; (7) pre-addition of stoichiometric quantities of ferrocyanide to the metmyoglobin before formation of peroxide compound almost eliminated the free radical. Such treatment was found by George and Irvine[5] to titrate the oxidizing equivalent of hydrogen peroxide lost during the formation of the peroxide compound.

These experiments suggest that the free radical is not the peroxide compound itself, but a product of oxidation by the other oxidizing equivalent, considered by George and Irvine[5] to be a hydroxyl radical, OH·. The oxidized product is probably part of the globin molecule.

That the formation of the actual peroxide compound involves changes in the binding of the iron atom was demonstrated by an experiment at a magnetic field value in the region where g is 6. Under these conditions, the five unpaired paramagnetic electrons of free metmyoglobin give an *ESR* signal that is quenched when the peroxide compound is formed. This evidence of a change from ionic to covalent binding is in agreement with measurements of paramagnetic susceptibility[4].

Another type of free radical, involving removal of a methene bridge hydrogen atom, was considered by George and Irvine[5] as a possible alternative to the ferryl structure. Such a free radical would be expected to produce *ESR* microwave absorption with a g value slightly greater than 2, owing to the introduction of an orbital component in the magnetic moment of the more localized unpaired electron. No such absorption is observed.

Preliminary experiments on solutions of peroxidase show that the amount of free radical produced is very small compared with the concentration of peroxide compound II. This is in agreement with the similar *ESR* results obtained by Chance and Fergusson[6] using freeze-dried material. Whether small quantities of free radicals other than enzyme peroxide compounds occur must await an improvement in the sensitivity of the present apparatus.

These results therefore support the view that the oxidizing equivalents of secondary hæmoprotein peroxide compounds are associated with the iron atom itself. The occurrence of a free radical in the metmyoglobin reaction is none the less of some interest. It is an example of a reversible univalent oxidation state in a biological system, not involving valency changes of a transition metal. Whether

similar oxidation states occur in any reactions of physiological importance, however, is not known.

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A New Transaminase of *Corynebacterium diphtheriae*

According to Shemin *et al.*[1,2] δ-aminolævulinic acid is not only utilized for porphyrin synthesis, but has also to be considered as an intermediate in the formation of purines. Very little is known at present about the enzymes responsible for this conversion. Shemin suggests the deamination of δ-aminolævulinic acid. Recently, Kowalski *et al.*[3] succeeded in demonstrating a δ-aminolævulinic acid transaminase system in mammalian tissues.

During our studies on the porphyrin metabolism of *Corynebacterium diphtheriae* we demonstrated transaminase activity in some cell-free bacterial extracts on δ-aminolævulinic acid/α-ketoglutarate and also on δ-aminolævulinic acid/pyruvate systems.

The cell-free extracts were prepared by grinding the cell mass mechanically, with glass powder in a Potter–Elvehjem homogenizer, followed by extraction with 0·05 *M* phosphate buffer (*p*H 7·6) and dialysis overnight against the same buffer.

To 1·7 ml. of this buffered cell-free extract, containing 2–4 mgm. protein per ml., were added 0·1 ml. phosphate buffer (*p*H 8·0), 0·2 ml. of 0·2 *M* δ-aminolævulinic acid, and either 0·2 ml. of 0·3 *M* α-ketoglutarate, or 0·2 ml. 0·5 *M* pyruvate. The mixture was incubated at 35° C. and then deproteinized with ethanol.

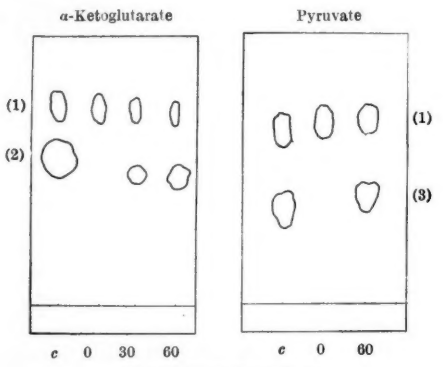

Fig. 1. Paper chromatograms of 75 μl. portions of an alcoholic extract of the incubation mixture, on Whatman No. 1 filter paper, chromatographed in *n*-butanol/acetic acid/water, 4 : 1 : 5. (1) δ-Aminolævulinic acid; (2) L-alanine; (3) L-glutamic acid; *c*, control

The reaction products were separated by paper chromatography and the spots were located by spraying with 0·2 per cent alcoholic ninhydrin solution.

The results are shown in Fig. 1. The transamination takes place with both α-ketoglutarate and pyruvate as amino-group acceptors; glutamic acid and alanine are formed respectively.

These findings suggest that there are at least two ways in which certain micro-organisms can utilize δ-aminolævulinic acid: one, the condensation to porphobilinogen, catalysed by a dehydrogenase which Gibson *et al.*[4] found to be very active in *Corynebacteria*; the other, by transamination, catalysed by a hitherto unpurified enzyme. So far as I know no such enzyme has been described in any bacteria hitherto.

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Feb. 25.

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Changes in Vat Dye Systems

When certain vat dyeings on textile substrates are given an after-treatment, such as boiling in water or dilute soap solution, there is a change in the colour of the dyeing[1]. We have found that when changes of this kind occur with dyed 'Cellophane' the absorption spectrum becomes very similar after treatment to that of the corresponding solid-dye film on quartz, prepared in the manner already described[2]. In our experiments 'Cellophane' (deplasticized, British Cellophane, Ltd., *PT*300, 0·00085 in. thick) was dyed in the normal way from a solution of the vat dye in caustic soda and sodium hydrosulphite. The leuco dyeing was oxidized in air, washed in cold water for 5 min. and dried flat in air. The absorption spectrum of the air-dry dyeing was measured before and after subsequent aqueous treatments.

The results for 1 : 5-dibenzoylaminoanthraquinone (prepared from the monobenzoyl derivative and recrystallized from nitrobenzene) on 'Cellophane' and in the solid state are given in Fig. 1. On storing the dyed 'Cellophane' in water at room temperature for one month, or on boiling with a soap solution for 30 min., the visible absorption band is displaced bathochromically in the direction of the band in the solid state. There is also the appearance of a new band near 240 mμ which is present in the solid state but not in the original dyed 'Cellophane'. Results of a similar type were obtained with 1-benzoylaminoanthraquinone (purified by recrystallization from ethyl alcohol, melting point 254° C.). The visible absorption band was observed at 410 mμ in 95 per cent ethyl alcohol, at 450 mμ in the solid state, and the dyed 'Cellophane' at 444 mμ before treatment and at 464 mμ after aqueous treatment. From the reasoning of Weinstein and Wyman[3], it would seem

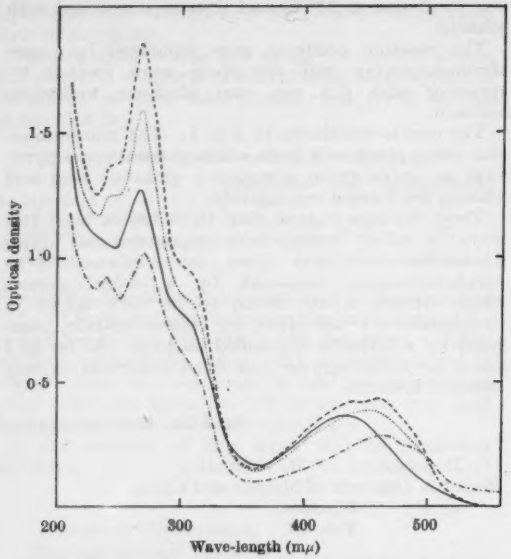

Fig. 1. The absorption spectrum of 1 : 5-dibenzoylaminoanthraquinone. — · —, solid film on quartz; dyed 'Cellophane', ———, without further treatment; – – –, dyeing boiled in 0·25 per cent soap solution for 30 min.; ...., dyeing stored in distilled water in dark at room temperature for 30 days

likely that these changes with benzoylaminoanthraquinone derivatives are the result of association of the molecules by hydrogen bonds.

Not all changes in the absorption spectra of dyed 'Cellophane' can be explained in this way, however, and with thio-indigo dyes *cis–trans* isomerism seems to be involved. Wyman and Brode[4] have shown that the absorption spectra of these dyes in organic solvents depend upon the relative proportions of the *cis* and *trans* forms. The *trans* configuration is assigned to the more stable form, and possesses a visible absorption band at a considerably longer wave-length than the *cis* form. 'Cellophane' (Fig. 2) dyed with 1′-acenaphthene 2-thianaphthene indigo (recrystallized from nitrobenzene, melting point 271° C.) appears to contain immediately after oxidation a

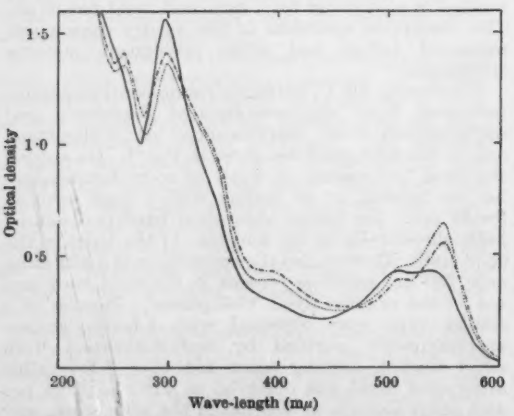

Fig. 2. The absorption spectrum of 1′-acenaphthene 2-thianaphthene indigo. — · —, solid film on quartz; dyed 'Cellophane', ———, without further treatment; ...., dyeing stored in distilled water in dark at room temperature for 30 days

proportion of the *cis* and *trans* forms which is altered on boiling with a soap solution, or on long storage in water at room temperature, the amount of the *trans* form increasing as a result of these treatments. The spectrum of the solid film of this dye is very similar to that of the after-treated dyeing on 'Cellophane'.

These results suggest that with 'Cellophane' dyed with benzoylaminoanthraquinone and thio-indigo dyes there is a tendency for the dye, on after-treatment, to undergo a change towards the condition of the dye in the solid state free from polymeric material. Since there is evidence[5] that the photochemical stability of dyes is greater in the solid state than in a polymer mass, the explanation of the high light fastness of vat dyeings on cellulosic materials would seem to lie in the fact that in most cases the vat dyes are present in the textile material after the technical process of soaping as solid discrete dye particles. The difficulty of removing these dyes by washing from the textile material in normal use presumably arises from the large size of the dye molecules and aggregates and the small size of the pores in the textile material, rather than in any bond between the dye and fibre. Thus, 1′-acenaphthene 2-thianaphthene indigo, which is soluble in ethyl alcohol, can be stripped by boiling alcohol from dyed cotton but not viscose rayon. It is known that in the unswollen state the pore size of the latter fibre is much smaller than that of cotton.

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Exothermic Reaction of Metakaolin between 950° and 1,000° C.

Recently, Wiegmann and Horte[1] have discussed the exothermic reaction of metakaolin and concluded that it is due to the formation of sillimanite. Opinion on this question has long been divided. Some[2] ascribe the reaction to the crystallization of γ-Al_2O_3, whereas others[3] ascribe it to the formation of mullite by rearrangement of the metakaolin lattice, yielding a residue of γ-Al_2O_3 and amorphous silica. The claim that sillimanite rather than mullite forms at the exotherm re-introduces a hypothesis that has long gone out of favour[4,5]. The evidence put forward by Wiegmann and Horte is difficult to dispute but nevertheless the results of our work do not agree with theirs.

By studying the area of the exothermic reaction on differential thermal curves for a series of co-precipitated gels of alumina and silica, Wiegmann and Horte found that the maximum area was given at an SiO_2/Al_2O_3 ratio of 1 : 1, the composition of sillimanite. In the case of a ratio less than 1 they found γ-Al_2O_3 in addition to the sillimanite, but no other phase was mentioned for ratios greater than 1.

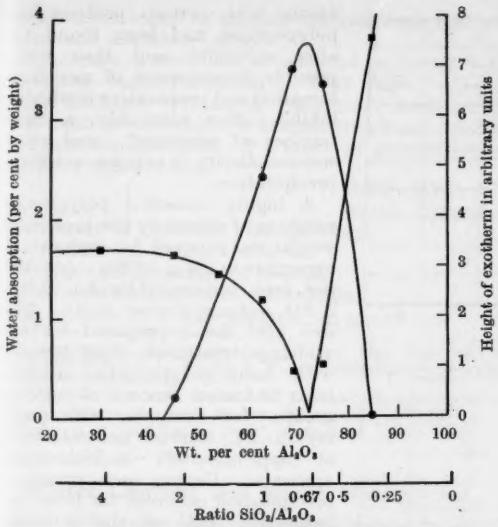

Fig. 1. Plot of water absorption (■) and height of exothermic peak (●) versus composition for a series of co-precipitated gels of silica and alumina. The water absorption is for samples dried at 110° C. after firing to 1,000° C. and autoclaving at a pressure of 200 lb./in.² until the samples attained a constant weight. The heights of the exothermic peak were recorded on automatic differential thermal analysis equipment

We have studied a similar set of co-precipitated gels by the differential thermal method and found that the maximum thermal effect is given at an SiO_2/Al_2O_3 ratio of 0·67, the composition of mullite (Fig. 1).

The product after the exothermic reaction for an SiO_2/Al_2O_3 ratio of 1 : 1 was a mixture of a silicate phase and amorphous silica, and for a ratio of 0·76 and less a mixture of a silicate phase and γ-Al_2O_3. It is on the question of the identification of the silicate phase that we differ from Wiegmann and Horte. They claimed that it is not possible to distinguish between sillimanite and mullite by X-ray diffraction techniques, citing De Keyser[6]. However, De Keyser actually showed that the two minerals could be distinguished if an X-ray spectrometer of suitable dispersion were used. Scholze[7] reached the same conclusion after examining samples in a Guinier-type focusing camera of 114·6 mm. diameter. We have used an X-ray camera similar to that used by Scholze, and have concluded that the silicate phase formed after the exothermic reaction in co-precipitated gels of alumina and silica is a disordered phase characteristic of mullite. Heating the samples to 1,200° C. improved the crystallinity of the silicate, and by comparison with the data in the literature[6,7] the X-ray pattern was that of mullite. At no stage was a pattern like sillimanite obtained; hence we conclude that the phase produced in the exothermic reaction from co-precipitated gels of silica and alumina is mullite. Letort[5] reached a similar conclusion from X-ray and infra-red absorption data.

In our work we prepared gels, by the same method as Wiegmann and Horte, to study water absorption movements after firing. These movements are a minimum at an SiO_2/Al_2O_3 ratio of 0·67 (mullite), which corresponds exactly with the composition at which the height of the exothermic reaction is a maximum (Fig. 1). At a ratio of 1 : 1, the composition of sillimanite, there is an appreciable water absorption which we ascribe to amorphous silica, since the presence of this material is indicated by X-ray analysis. Although these results are self-consistent we find that when γ-Al_2O_3 is present in our samples the amount is higher than would be expected if mullite formed at the exotherm, and we have concluded that the co-precipitation of our gels, although carried out very carefully, was not perfect. The same criticism would seem to apply to the gels prepared by Wiegmann and Horte. It is extremely difficult (and may be impossible) to avoid precipitating a certain amount of alumina as boehmite. This may result in a product with a higher SiO_2/Al_2O_3 ratio than intended, or an excess of amorphous silica to balance the alumina precipitated as boehmite. (The latter hypothesis is supported by the fact that in gels with SiO_2/Al_2O_3 ratios of 0·76 and 0·57 the γ-Al_2O_3 disappears by reacting with amorphous silica to make secondary mullite when the samples are heated to 1,200° C.) In view of the difficulties just raised it is perhaps not surprising that we place the maximum thermal effect at an SiO_2/Al_2O_3 ratio of 0·67, Wiegmann and Horte at 1·0 and Insley and Ewell at between 1 and 2. In our opinion, the use of such indirect evidence to identify the phase formed in heating co-precipitated gels of silica and alumina is unsound.

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Molecular Sieves as Subtractors in Gas Chromatographic Analysis

SYNTHETIC zeolites of the 'molecular sieve' (Linde Division, Union Carbide Corp.) type have been widely used in gas chromatography in light-gas analysis, particularly for oxygen–nitrogen separations.

An interesting additional property of molecular sieves is their selective retention of *n*-paraffins in mixtures of *n*-paraffins, *iso*paraffins, *cyclo*paraffins and aromatics.

Benzene, toluene, ethylbenzene, xylenes, *cyclo*hexane, methylcyclopentane, 2- and 3-methylpentane, 2,2-, and 2,4-dimethylbutane, and other *iso*- and *cyclo*paraffins were found to be virtually unretarded when passed through short (30 cm.–1 m.) columns of 5 A. pore diameter molecular sieve at temperatures of 60–180° C. The *n*-paraffins from C_3 to C_{11} were found to be irreversibly adsorbed.

Fig. 1 (top) shows a gas chromatographic separation of a portion of a sample which is a product of a petrol-

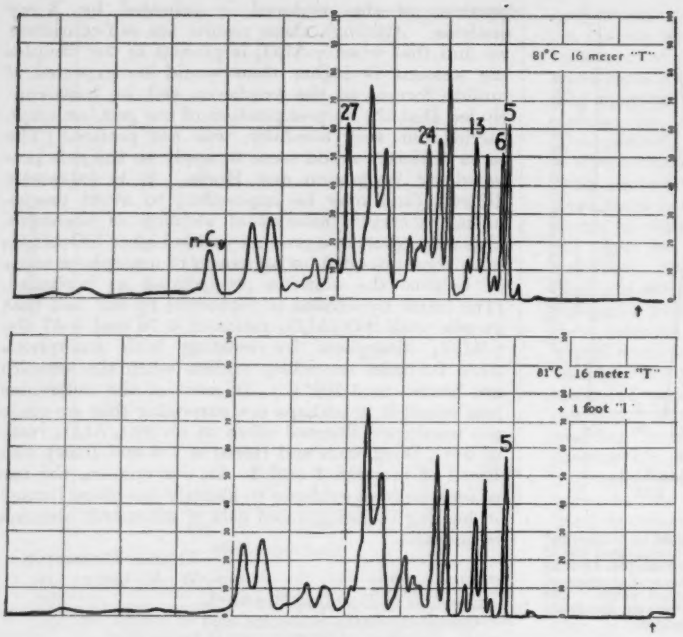

Fig. 1. *n*-Paraffin subtraction by molecular sieves. Top, partition column; bottom, partition column plus molecular sieve. Components: 5, *iso*pentane; 6, *n*-pentane; 13, *n*-xylene; 24, normal heptane; 27, normal octane.

eum-reforming process (column: 50 ft. *BB* oxydipropionitrile on 30–60 mesh Johns Manville 'Chromosorb', temperature 81° C., pressure drop 30 lb./in.²).

Fig. 1 (bottom) shows the same separation under the same conditions except that a 20-cm. molecular sieve column has been added in series with the partition column. The missing bands are the *n*-paraffins from propane to *n*-nonane inclusive.

This procedure facilitates rapid identification of bands of *n*-paraffins in hydrocarbon analyses. It is also useful in gasoline analysis since *n*-paraffins as a group are significant in the lowering of octane number.

It should be noted that molecular sieves also show similar selective irreversible adsorptivity with respect to other homologous series.

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Interaction between Synthetic Polyglucose Sulphate and Biologically Active Basic Polypeptides and Proteins

Synthetic polysaccharides can be prepared from simple carbohydrates differing not only in molecular weight but also in degree of branching[1]. From such polyglucoses, various charged derivatives can be prepared, for example, a series of sulphuric acid esters with different degrees of sulphonation. The synthetic polysaccharide derivatives provide a system of 'macro-anions' the composition, macromolecular and polyelectrolyte properties of which can be altered systematically. Interaction of other kinds of macro-anions with certain proteins and polypeptides had been found to: alter solubility and thus make possible development of new fractionation and preparative methods[2]; inhibit, often reversibly, a large number of enzymes[3]; and show some similarity to antigen–antibody precipitation.

A highly branched polyglucose sulphate of relatively low molecular weight was selected for exploratory experiments (M_n, 18,300; $[\eta]$ (0·5 per cent sodium chloride), 0·05; 3 SO_4/anhydroglucose unit). The free acid form, prepared by ion exchange treatment, when titrated with basic polypeptides or proteins of known content of cationic groups (for example, with polymyxin *B*), showed neutralization at approximately stoichiometric amounts. During such titrations precipitation occurred far from the isoelectric point of the proteins, depending on *p*H, salt and polyelectrolyte concentration. No similar precipitation can be obtained with sulphuric acid, sodium sulphate, or a glucose tetrasulphate. For example, an aqueous solution of an adrenocorticotrophic hormone preparation, which had a *p*H of 3·4 and remained soluble in the presence of sulphuric acid, formed a heavy precipitate with the free macro-anion at *p*H 1. Analogous precipitates were obtained, at appropriate *p*H values, with: a basic thymus peptide; protamine sulphate; lysozyme; crystalline ribonuclease; human serum albumin; and the non-polypeptide neomycin *B*. The insoluble free basic form of polymyxin *B* dissolved upon interaction with polyglucose sulphate, but this yielded a precipitate in the presence of sodium sulphate.

When the polyglucose sulphate was dialysed exhaustively through 'Cellophane' (20 per cent weight loss), the residual higher molecular weight product precipitated more completely the macro-cations at the optimum *p*H.

By alteration of the *p*H or ion concentration, soluble interaction products were formed by all the above macro-cations, and these co-migrated upon electrophoresis at *p*H 3, 7 and 10; with the exception of the serum albumin complex, which dissociated at *p*H 10 and was completely insoluble at the other *p*H values. In contrast to these results the neutral salts of the macro-cations formed with a low molecular weight anion (glucose tetrasulphate) dissociated freely upon electrophoresis, as did the salts of polyglucose sulphate with basic amino-acids.

The reversible inhibition of two basic enzymes, ribonuclease and lysozyme, was demonstrated *inter alia* with the polyglucose sulphate.

Ribonuclease activity was measured[4] by following the absorption changes at 300 mμ. Complete inhibition of 0·02 mgm. ribonuclease was obtained with 1 mgm. of macro-anion, and about 80 per cent inhibition with 0·5 mgm. When lysozyme was added, 0·5 mgm. lysozyme gave 50 per cent reversion, and 1 mgm. completely reversed the inhibition. Similar reversion was obtained with protamine

sulphate. 1 mgm. of glucose tetrasulphate had no significant inhibitory effect.

Lysozyme activity on a bacterial substrate was measured turbidimetrically[5]; 0·03 mgm. macroanion inhibited 0·06 mgm. lysozyme. Addition of 0·06 mgm. of protamine or 2 mgm. of sodium chloride reversed the inhibition. 0·2 mgm. of glucose tetrasulphate had no effect.

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Water Content and Insect Metabolism

It is well known that substantial changes in water content may occur in some insects. The hæmolymph, for example, which may be copious and watery in a recently fed individual, may become scanty and treacly in a starved and desiccated specimen[1]. Reversible desiccation may slow down metabolism; it may be important in promoting survival in species exposed to very low (sub-zero centigrade) temperatures, but it may have remarkably little effect on many vital processes.

The larva of the mealworm beetle (*Tenebrio molitor* L.) may have a low or a high water content. Larvæ from a culture in bran have approximately 42 per cent of dry matter and 58 per cent of water. If these insects are given an opportunity to drink, they take up a quantity of water equivalent to about half their body-weight. As there is no corresponding increase in dry matter, this results in their having now approximately only 25 per cent of dry matter and 75 per cent of water in their bodies. The water enters the gut, but soon is found in the hæmolymph, the volume of which increases greatly after drinking. Larvæ which have drunk are easily distinguished from those which have not; they are inflated, the cross-section of the body is more nearly circular, and the intersegmental membrane is extended and visible between the segmental sclerites. Both 'dry' and 'wet' larvæ can, under favourable conditions, complete their development and produce normal adults (which still show comparable differences in water content).

Mealworms lose water slowly in dry air. Those which have recently drunk, and have a high water content, lose that water as slowly as do more desiccated individuals. There are considerable variations between individuals, but when a batch of individuals with 42 per cent of dry matter was exposed to 30° C. and 0 per cent relative humidity for 25 days, it lost 20·25 per cent (S.D. ± 2·3) of its initial weight; the loss under the same conditions by a group which had all drunk water, and contained only 25 per cent dry matter, was very similar (20·6 per cent, S.D. ± 2·0). This loss of weight is almost entirely due to water evaporated from the insects. The water, newly taken in by drinking, was therefore conserved as carefully as the much smaller amount present in the less-hydrated individuals.

Mealworm larvæ from these two groups, with high- and low-water contents, behaved very similarly to high and low temperatures. When they had been kept at 18° C. for 24 hr. or longer, both lots had the same thermal death-point[2] for an exposure of 1 hr., namely, 42° C. When transferred to 35° C., both groups were equally rapidly acclimatized, and had a thermal death-point (again for an exposure of 1 hr.) of 44° C. Recovery from heat coma by larvæ given sublethal exposures to high temperatures was similar in individuals with high- and low-water contents.

The chill coma temperature, the speed of acclimatization to low temperatures, and the rate of recovery from chill coma were also similar in both groups of larvæ. Thus I took larvæ acclimatized to 18° C. and chilled them to 0° C., when they were completely immobilized; when returned to 18° C., those with 42 per cent of dry matter recovered in 35–55 min. (mean 43 min.), those with 25 per cent dry matter recovered in 30–50 min. (mean 40 min.). These differences are not statistically significant, and the behaviour of the two groups was generally indistinguishable.

The similarity in the behaviour of these two groups of the same species of insect with such different water contents does not make it any easier to explain the cause of heat death, of chill coma or of acclimatization to high and low temperatures; but it does perhaps restrict the number of tenable hypotheses to explain these phenomena.

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An Apparent Beneficial Effect of Gamma-Radiation on the Flour Mite

Insect pests of cereal products have been found to differ markedly in their tolerance to γ-radiation, but of 17 species examined by Cornwell *et al.*[1] 13 were sterilized at about 6×10^3 rep. Recently, however, Cork[2] has suggested that the life-span of the flour beetle *Tribolium confusum* may be extended by a single dose of 3×10^3 r. A comparable beneficial effect on the flour mite *Tyroglyphus farinae* (Deg.) was also suggested by the following work.

Replicate cultures of *T. farinae* in wheat flour were exposed to γ-radiation from a cobalt-60 source. These and untreated controls were incubated at 22·5° C. and 85 per cent relative humidity for 42 days. It was observed that living mites were present in all the cultures at the end of this period. At weekly intervals the hatched and unhatched eggs were counted by a technique described elsewhere[3]. An increase in density of hatched eggs represented an addition of new individuals to the population and measured the natality rate per unit time[4]. The total egg density indicated the ability of the population to survive.

From the results in Fig. 1 it appeared that a single irradiation at 5×10^3 and also at 10^4 rad resulted in a significant increase in the numbers of eggs laid and hatched when compared with the control. Oviposition continued throughout the period, whereas in the control both oviposition and hatching were

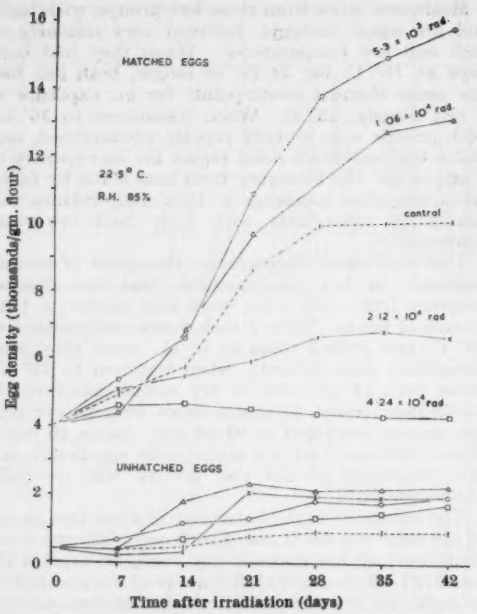

Fig. 1. Egg densities of *T. farinae* after γ-irradiation

negligible after 28 days. In contrast, irradiation at 2×10^4 rad significantly reduced the numbers of eggs laid and hatched and at 4×10^4 rad hatching was negligible, although oviposition continued throughout the period. The total egg density indicated that 4×10^4 rad sterilized the population. With this organism, therefore, it was concluded that irradiation insufficient to sterilize may actually lead to an increase in the production of fertile eggs. These observations will be continued over longer periods.

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Biochemical Differences between Inbred and Outbred lines of *Drosophila melanogaster* studied by Paper Partition Chromatography

Using the techniques of paper chromatography described by Hadorn and Mitchell[1] and Buzzati-Traverso[2], a study of the physiological processes of ageing of *Drosophila melanogaster* was undertaken in four stocks in which two systems of mating had been established. Two of these four stocks were highly inbred (404–407 generations for Oregon and 294–297 generations for Samarkand, with inbreeding broken at the hundredth generation by one generation of cousin-mating; Scossiroli, R., personal communication); the other two stocks, also of Samarkand and Oregon, were mass mated. The fluorescent compounds found are in agreement with those found by Hadorn and collaborators (personal communication).

During ageing of the mass-mated stocks a typical and constant pattern of nine fluorescent compounds is found. The inbred lines do not show this constancy[3], and at any given stage appeared to lack some fluorescent compounds. We were able to determine that at least five of the nine compounds were affected in some way by the inbreeding level of our stocks. The compounds were: xanthopterin[4] (our green spot, No. 4); spot No. 6 (possibly a complex of two compounds[5]); spot No. 8 (our blue spot; kynurenin[6]); and spot No. 9, which appears in small amounts. Inbreeding tended to eliminate or conceal these compounds, and also revealed its effects on the processes of ageing of our inbred stocks by decreasing the fluorescence of these compounds when they were present. In this respect fluorescence of kynurenin from inbred females and that of *iso*xanthopterin[7] were affected considerably. The presence of kynurenin in the eggs of *Drosophila* has been demonstrated by others[1]. Inbreeding, therefore, seems to have affected the 'normal' occurrence of this compound in the females of our stocks.

Recent work by Robertson and Forrest[8] has also demonstrated that there is a very significant difference in *iso*xanthopterin between inbred and wild stocks of *Drosophila*.

We consider the low fluorescence in the compounds mentioned in Table 1 to be indicative of the effects of inbreeding on the general process of ageing in *Drosophila melanogaster*. The uniform and strong fluorescence displayed by the outbred stocks of this species can be interpreted as resulting from well 'canalized'[9] ageing processes.

Table 1

Stocks	Spot No.	n	Fluorescence (arbitrary units)	t values	Degrees of freedom	99 per cent confidence
♀♀ Inbred Samarkand	8	22	50·04	4·6	21	very significant
♀♀ Outbred Samarkand	8	22	76·45			
♀♀ Inbred Oregon	8	26	58·00	26·08	25	very significant
♀♀ Outbred Oregon	8	26	88·00			
♂♂ Inbred Oregon	3	27	70·77	11·13	26	very significant
♂♂ Outbred Oregon	3	27	93·00			
♂♂ Inbred Samarkand	3	16	76·14	0·80	15	not significant
♂♂ Outbred Samarkand	3	16	70·12			

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Demonstration of Thyroglobulin in the Presence of Other Proteins by the Precipitin Reaction

RECENTLY Doniach and Roitt[1] found that the sera of patients with Hashimoto's disease contained auto-antibodies to human thyroglobulin. They demonstrated this by diffusion-precipitation reactions in agar gels. Positive precipitin reactions were obtained by allowing the sera to react with saline extracts of human thyroid or purified thyroglobulin. We have investigated the possibility of using this precipitin reaction in an immuno-electrophoretic method for the demonstration of thyroglobulin in the presence of other proteins.

A saline extract containing radioactive thyroglobulin was prepared from a section of a thyrotoxic gland removed at operation from a patient who had previously been given radioactive iodine. The tissue was frozen, thinly sliced and shaken for 30 min. with 3 parts normal saline, and allowed to stand overnight at 2–3° C. The extract was centrifuged, and the supernatant liquid stored in the deep freeze. Our immuno-electrophoretic technique was similar to that employed by Kohn[2], except that electrophoresis was carried out on Whatman 3 *MM* paper. 30 µl. of the radioactive extract was electrophoresed in barbitone buffer, *p*H 8·6. Two strips were run. Immediately after electrophoresis, one strip was placed on an agar slab (1 per cent Davis standard agar in normal saline), 0·5 cm. away from a piece of filter paper 3 mm. × 13 cm., impregnated with serum known to give a strong precipitin reaction. The agar slab was placed in a moist chamber, and left to stand at room temperature. The proteins diffused into the agar, and precipitin lines developed four to eight days later. When the zones were clearly visible the agar slab was dried, and stained for six hours in a solution of bromphenol blue[3]. After staining, the preparation was washed in 5 per cent acetic acid until the background was clear. It was then placed in a solution of 10 per cent glycerine in 2 per cent acetic acid for 30 min., before drying at room temperature.

The radioactivity on the second strip was recorded, using two scintillation counters. Afterwards, it was stained in bromphenol blue and used as a marker strip.

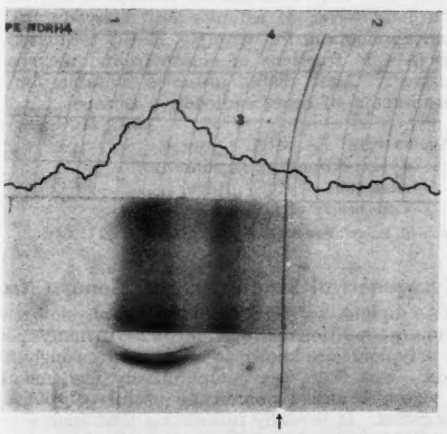

Fig. 1. Paper electrophoresis of thyroid extract at *p*H 8·6. The marker strip (*B*) stained with bromphenol blue is aligned with record of radioactivity (*A*) and stained agar film (*C*) showing precipitin zone. The arrow indicates the origin

From Fig. 1 it will be seen that the maximum radioactivity recorded is associated with the fastest moving fraction, and this is also where the precipitin zone is found. The radioactivity of the thyroid extract was not extractable with butanol, and the radioactive fraction was found to have a mobility at *p*H 8·6 between that of the α_1 and α_2 serum globulins. Robbins *et al.*[4] found that the sera of patients after iodine-131 therapy contained a protein which, by salting-out procedures, and ultracentrifugal sedimentation was indistinguishable from thyroglobulin. Electrophoresis at *p*H 8·6 did not differentiate between thyroxine-binding protein and a thyroglobulin-like protein[5].

After electrophoretic separation of the α-globulins in selected sera, it is proposed to apply the technique described in an attempt to demonstrate the presence of circulating thyroglobulin, particularly after iodine-131 therapy.

We wish to thank Miss Helen E. A. Farran for the measurement of radioactivity.

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Effect of a Dithiol on Survival Time after Irradiation

CONTRARY to previous reports[1], Doherty *et al.*[2] obtained partial protection of X-irradiated mice with 2,3-dimercaptopropanol. If a foreign dithiol compound is effective perhaps the dithiol form of an essential metabolite might also prove beneficial in radiation injury. Mice were exposed to 550 r. acute whole body X-irradiation under our usual conditions[3]. The animals received 50 mgm./kgm. of DL-6,8-dithioloctanoic acid, the reduced form of thioctic acid, according to the schedule in Table 1. It is evident that the compound significantly increased the *ST*50 day, particularly if administered prior to irradiation. However, it has no real effect in reducing total mortality. The mechanisms involved in such partial protection are obscure, but dithiols are known to form resonance-stabilized radicals which could interact with the various oxidizing radicals produced by

Table 1. EFFECT OF 6,8-DIHYDROTHIOCTIC ACID ON SURVIVAL TIME IN IRRADIATED MICE

Treatment	*ST*50* and range (days)	Slope and range	Mortality Ratio	Mortality Day
Saline control	5·7 (4·9–6·6)	1·41 (1·27–1·56)	20/20	12
6,8 Dihydrothioctic acid†				
1 day pre-irradiation	9·8 (8·2–10·5)	1·33 (1·22–1·45)	20/20	19
10 min. pre-irradiation	9·3 (8·6–11·2)	1·35 (1·23–1·49)	20/20	20
10 min. post-irradiation	6·8 (6·2–7·6)	1·31 (1·21–1·42)	20/20	14
1 day post-irradiation	7·7 (6·8–8·8)	1·36 (1·25–1·49)	19/20	20
Control	—	—	0/19	20

* *ST*50, day upon which 50 per cent of animals are expected to be still alive. Confidence limits are calculated at $P = 0{\cdot}05$, ref. 4.
† 50 mgm./kgm. intraperitoneally.

ionizing radiation. Such reactions could be continuous until the dithiol was completely destroyed. If the proportion of dithiol to oxidizers was in favour of the latter, this could explain the increased *ST*50 day and the unaffected total mortality observed in the group receiving the dithiol immediately prior to irradiation. Pre-irradiation medication could also result in protection of radiosensitive groups in the tissues by direct combination, but it might be difficult to obtain complete coverage. Post-irradiation medication could assist in breaking the chain reaction involving organic peroxides[5] but still not prevent the early damage which would tend to decrease total survival. Thus it would appear that a dithiol can increase survival time, possibly by the above mechanisms, yet give no permanent protection against the lethal effects of ionizing radiation.

We wish to thank American Cyanamid Co. for the DL-6,8-dithioloctanoic acid. This work is based on work performed under Contract No. *AT*-04-1-*GEN*-12 between the Atomic Energy Commission and the University of California at Los Angeles.

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A Direct-Plating Method for the Precise Assay of Carbon-14 in Small Liquid Samples

When aqueous solutions containing carbon-14 compounds are dried on planchettes for assay under an end-window counter, surface tension often makes it difficult to ensure that the solids are deposited in a layer sufficiently uniform to give reproducible self-absorption and counter geometry. The essential feature of the present method is that the compound to be assayed is incorporated in a layer of gel which will dry to a perfectly even film.

Agar is first dissolved on a boiling water-bath to make a 2 per cent sol, which is drawn into lengths of precision glass tubing of 3 mm. bore, and there allowed to solidify. A cotton-wool plug, inserted into one end of such a tube, is pushed along it with a rod to extrude a cylinder of agar gel. This cylinder is sliced into blocks 3 mm. long with a cutter consisting of 17 spaced safety-razor blades. By passing the teeth of a comb between the blades, the 16 agar blocks are expelled on to a glass slip, from which they are all transferred to a standard flat-bottomed planchette of nickel-plated steel, 25 mm. in diameter and 2 mm. deep. (Before use each planchette must be briefly heated to redness, to ensure adherence of the dried agar film.) The solution to be assayed is pipetted on to the planchette bearing the agar blocks. It is convenient to take a volume of 0·8 ml., the maximum which can be accommodated on each planchette; if the volume of the sample is smaller, water is added until the planchette is just filled.

The planchettes so prepared must now be heated sufficiently to disperse the agar, and this must be done in a saturated atmosphere to prevent evaporation. One method is to place the planchettes in Petri dishes, covered by lids lined with filter-papers saturated with water. A small central hole in each filter-paper prevents it from being sucked down on to the samples as the dish cools. The dishes are placed in an oven at 105° C. for 20 min., and are then withdrawn for inspection; the agar blocks should have disappeared completely, and gentle swirling will ensure uniform distribution of the agar. The filter-papers are removed and the dishes are left to cool on a horizontal surface until the agar has set. The details of the heat treatment may need modification to suit the particular agar used.

By this procedure the liquid in each sample is immobilized in a uniform layer of dilute agar gel. The planchettes are next exposed to a current of air under an infra-red lamp, and in about an hour the gel dries to a hard, stable, uniform film of low and reproducible self-absorption. The weight of agar in the film is about 1·5 mgm./cm.^{2}, and less than 20 per cent of the radiation from the carbon-14 in it is lost by self-absorption due to the agar. Solutes in the sample may, of course, add significantly to the self-absorption.

Although the dried agar film is slightly hygroscopic, exposure to a saturated atmosphere does not normally alter the count; strongly hygroscopic solutes might, however, cause errors. Another limitation of the method is that the solution to be assayed must contain no constituent (such as acid) which would interfere with the setting of the agar. Obviously none of the carbon-14 must be in a volatile form. Some solutions tend to creep over the edge of the planchette; this can be controlled by smearing the lip of the planchette with a trace of silicone grease.

To test the precision of the agar-plate method, 10 replicate determinations were made on 0·8 ml. samples of a solution containing carbon-14. Counts of the order of $1{\cdot}2 \times 10^6$ on each gave a standard deviation of $\pm$ 0·3 per cent, which is scarcely greater than the expected error due to random variations in the counting rate. As the planchettes with the agar blocks can be prepared beforehand, and afterwards processed in large batches, the method is convenient when long series of samples are assayed; it has found application, for example, in the estimation of carbon-14 in fractions of eluate from ion-exchange columns[1]. Agar plates are also suitable for the measurement of other radioactive isotopes.

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Cytogenetical Studies in the Genus *Citrus*

The diploid, $2n = 18$, seems to be a physiologically optimum condition in the genus *Citrus*. In many species the polyploids are known to arise spontaneously from seeds. But there are comparatively few instances of vigorous and economically useful polyploids in this genus. It is really interesting that such a large genus, having numerous species, should generally have the same chromosome numbers. With this idea in view, cytogenetical studies were undertaken to

investigate the cytological basis of speciation in this genus.

The karyological studies reveal clearly that structural changes have played a great part in speciation. During the course of investigations, we have already reported multivalent formation, for the first time in this genus, in the diploid species *C. assamensis*[1], thus proving it to be a structural hybrid. Further studies have revealed *C. penivesculata*[2] to be heterozygous for single inversion, which results in the formation of dicentric bridges and acentric fragments at both the divisions. Besides this anomaly, univalents numbering from two to four have been observed at metaphase I, which arise both as a result of lack of synapsis and precocious separation. Other abnormalities such as lagging univalents, unequal disjunction and univalents lying in the cytoplasm have also been observed at both the divisions.

A very interesting example of inversion heterozygosity is afforded by *C. limonia* var. Italian round. While the variety Italian oblong shows only two to four univalents at metaphase I and no bridge formation, the variety Italian round lemon shows bridge formation at anaphase of both the divisions.

In the genus *Citrus* both the segmental interchange and inversions seem to have played an important part in speciation. The most remarkable example of the first type is afforded by *C. assamensis* and the second type by *C. penivesculata* and *C. limonia* var. Italian round. The fact that the variety Italian round shows inversion heterozygosity, while there is no bridge formation in the variety oblong, is of great significance.

We have observed cytomixis for the first time in this genus. In *C. penivesculata*, partial or complete transference of nucleus from one pollen mother cell to another, resulting in a binucleate cell of normal size, has been observed. The giant binucleate pollen mother cells also seem to arise from the fusion of fully developed pollen mother cells. One such giant pollen mother cell (Fig. 1) has two separate metaphase I plates, each having a complete complement of 18 chromosomes, though the rest of these giant mother cells have single syndiploid spindles. One of the possibilities for the occurrence of such a binucleate mother cell could be that the fusion of two normal pollen mother cells occurred when the spindle formation had already begun in both the mother cells, thus avoiding the possibility of congregation of all the chromosomes on the single syndiploid spindle. That the fusion of fully developed pollen mother cells can take place has already been demonstrated in culture by Stern[3].

Fig. 1. (× 1,620)

Detailed results are being published elsewhere.

We are thankful to Prof. R. K. Saxena for providing the laboratory facilities and to (the late) Prof. W. B Hayes, of Naini Agricultural Institute, for providing the material.

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Multiplication of Solitary HeLa Cells

There are many occasions when it is desirable to grow animal cells from solitary inocula (for example, in order to obtain clones); for this reason, it seems worthwhile to record the following conditions which allow multiplication of isolated HeLa cells.

The method we have used is based on the technique developed by de Fonbrune[1] in which cells were isolated in small droplets of culture medium under paraffin oil. This method was employed by Lwoff *et al.*[2] for the study of virus release from single HeLa cells, but the uninfected cells failed to divide more than once under the conditions of their experiments. Subsequent modifications in technique similar to those reported here, however, have resulted in continued multiplication (Dulbecco, personal communication).

'Pyrex' glass Petri dishes, 60 mm. in diameter, were filled with about 30 ml. liquid paraffin (specific gravity, 0·865–0·890). Ten small droplets of medium were disposed under the oil upon the bottom of each Petri dish and a pool of about 100 cells was then put in its centre. The Petri dish was placed on the stage of a microscope which was fitted with a 2/3 in. objective and, under direct vision, one cell at a time was picked with a very fine Pasteur pipette which was connected to the mouth with a rubber tube. Then, again under direct vision, the cell was delivered into one of the waiting drops of medium. Provided that a small quantity of medium had previously been taken up into the capillary part of the pipette, it was possible to manipulate cells quite easily free-hand and to be reasonably certain that only one cell was delivered into each droplet. The Petri dishes were incubated at 37° C. in an atmosphere containing 6 per cent carbon dioxide and with a high relative humidity.

The most important condition was found to be the size of the droplet of medium. Fig. 1 shows the growth of single cells in droplets of varying size, and it will be seen that a diameter of 4·0 mm. is optimal (equivalent to 0·005 ml.). In smaller drops most of the cells disappeared and in larger drops there was a lag before they grew. Once the cells were growing exponentially the rate of growth was unrelated to the size of the droplets, and had a mean generation time of 24 hr., similar to that found in mass cultures.

The effect of droplet size is probably due to osmotic pressure change due to evaporation of fluid, even under the oil. Probably for the same reason we have found it best to use a deep layer of oil (at least

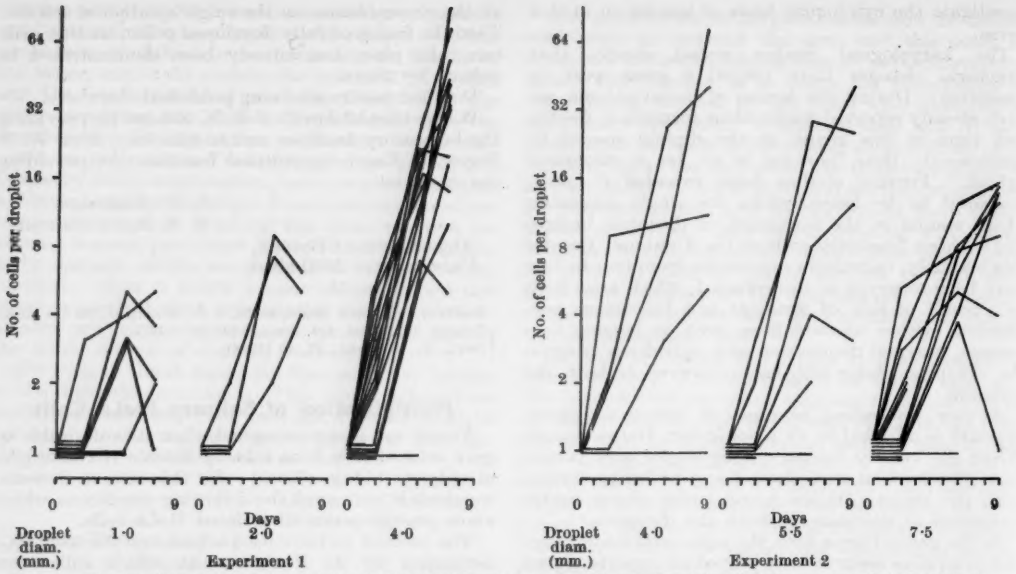

Fig. 1. The growth of solitary cells isolated in droplets of different sizes. In each experiment twenty cells were sown into droplets of each size indicated. The curves show the number growing and the extent of growth. Cells which disappeared are not indicated

Table 1. Growth of Single HeLa Cells to Visible Colonies

Showing the frequency of droplets with different numbers of cells on successive days after setting up 60 single-cell cultures

Days	Cells disappeared	No. of cells per droplet								Visible colony
		1	2	3–4	5–8	9–16	17–32	33–64	65–128	
0	—	60	—	—	—	—	—	—	—	—
2	24	13	15	7	1	—	—	—	—	—
4	26	4	3	2	6	8	9	2	—	—
6	28	3	2	2	2	9	9	3	2	—
8	29	2	3	—	4	2	5	8	3	4
12	34	1	1	1	1	1	3	1	3	14
17	34	—	4	—	—	1	—	1	—	20
20	39	—	—	—	—	—	1	—	—	20

10 mm.) which had been equilibrated by shaking with medium and leaving for some days at 37° C. Under oil, some drops of medium spread more widely on the glass than others, but this did not affect cell growth providing the volume was sufficient.

The stock cultures of cells were grown in Gey's or Earle's saline with 0·5 per cent lactalbumin hydrolysate and 20 per cent human serum. Comparisons of single cell cultures in medium with Gey's or Earle's saline and frozen or unfrozen human serum showed no difference, but replacement of 0·5 per cent lactalbumin hydrolysate with 10 per cent synthetic medium[3] yielded a higher proportion of dividing cells.

Not all the cells which began growing continued to do so indefinitely in either lactalbumin hydrolysate or synthetic medium. Table 1 shows the history of sixty cells in 4-mm. drops of Earle's lactalbumin medium, with medium changes every fourth day. In this series 24/60 failed to divide, 16/60 divided but later regressed, and 20/60 grew steadily to form colonies of several hundred cells visible to the naked eye. Such colonies may be subcultured by replacement of the medium in the drop by trypsin or versenate to detach the cells, before transfer to a tube. Even after the population has reached 10^4 and 10^5 cells in separate tubes, however, a clone may suddenly show an unexplained regression in all tubes simultaneously. This may be due to differences in the growth medium to which some clones may be more susceptible than others, and attempts are now being made to reduce the incidence of regression by more suitable media.

It will be seen that the method is suitable for obtaining clones of HeLa cells and indeed has two clear advantages over other methods. First, there is no doubt that each colony began as a single cell, because each cell was picked visually, and, secondly, because of the isolation of the droplets, there is no question of a clone becoming contaminated by wandering cells. The method is also of value for studies upon the growth of viruses in single host cells (cf. Lwoff *et al.*[2]). Finally, after quite a short apprenticeship, the technique is simple and certain; each solitary cell culture takes about thirty seconds to set up.

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A Specific Diffusible Antigen of Rinderpest Virus demonstrated by the Agar Double-Diffusion Precipitation Reaction

In recent years diffusible antigens of many viruses have been demonstrated by the double-diffusion precipitation reaction in agar. Early attempts in this laboratory to demonstrate such antigens associated with rinderpest virus failed, probably because the convalescent bovine and rabbit sera used did not contain a sufficiently high concentration of antibody.

An antigen was demonstrated, however, employing Mansi's modification[1] of Ouchterlony's technique[2] and hyper-immune serum prepared in rabbits. Rabbits were hyper-immunized by inoculation of the relatively avirulent, lapinized-avianized strain of rinderpest virus[3], followed seven days later by a series of four intravenous injections of the Nakamura III strain of lapinized virus, which is highly virulent for rabbits. The inoculum consisted of 1 ml. of a 25 per cent saline suspension of infected rabbit mesenteric lymph nodes; the interval between injections was two days and serum was collected seven days after the last inoculation.

Lymph nodes, preferably mesenteric, were collected from cattle killed at various stages after infection with the Kabete *O* strain of virulent rinderpest virus. These were homogenized, centrifuged and the supernatant fluid was used undiluted. No reaction was produced by lymph nodes of uninfected cattle but a strong single line of precipitation was produced within 24 hr. by nodes of infected animals harvested on the second day of the temperature reaction. The heaviest lines were produced by mesenteric nodes of cattle killed on the fifth day of pyrexia, the reaction thereafter diminishing, to disappear on the eighth day, presumably because of neutralization of the antigen by developing antibody.

Antigen preparations made as described above always produced an opaque haze 1–2 mm. wide around their depots, but the specific precipitate appeared in the remaining clear area between the serum depot and the edge of the hazy region. This haze was entirely eliminated if sodium chloride, usually used at 0·85 per cent concentration, was omitted from the diffusion medium, whereas the precipitation reaction was unaffected.

The stability of the antigen involved in this reaction has not been investigated in detail, but it is quickly destroyed in putrefying tissues, while addition of 0·4 per cent of formaldehyde or 0·5 per cent of phenol destroys it in a few hours. However, antigen preparations have been preserved for up to ten days at room temperature, without loss of activity, by addition of 1/10,000 thiomersalate. 1/10,000 thiomersalate is also incorporated in the diffusion medium. The antigen withstands drying at room temperature, as in the process described by Nakamura and Ishii[4] for the preparation of a complement-fixing antigen.

An antigen identical to that found in the lymph nodes of reacting cattle was detected in the mesenteric nodes of goats four days after infection with Kenya goat-attenuated rinderpest virus, in the rabbit lymph node inoculum used for hyper-immunizing rabbits and in infected tissue culture fluids[5] concentrated by the method of Svedmyr *et al.*[6]. Identity of the antigens in all cases was proved by the coalescence of the lines of precipitate formed.

This method of detecting rinderpest antigen in tissues may be of value in the diagnosis of suspected rinderpest outbreaks, especially in regions already free from the disease, as it is a rapid, simple technique and involves no inoculation of animals. It may also be of value in the differential diagnosis of rinderpest from diseases such as the mucosal disease complex of cattle, which may be confused with rinderpest on clinical and post-mortem examination.

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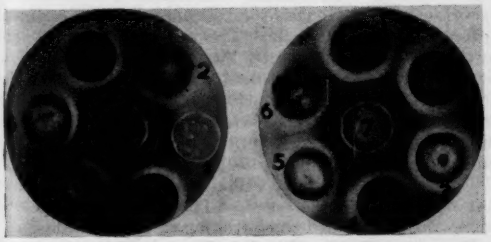

A *B*

Fig. 1. *A*: 1, Infected bovine lymph node; 2, infected goat lymph node; 3, concentrated infected tissue culture fluid; 4, infected bovine lymph node; 5, infected rabbit lymph node; 6, infected goat lymph node; 7, hyper-immune rabbit serum. *B*: 1, Normal bovine lymph node; 2, infected bovine lymph node; 3, normal rabbit lymph node; 4, infected rabbit lymph node; 5, infected goat lymph node; 6, normal goat lymph node; 7, hyper-immune rabbit serum

Cleavage in *Cheyletus eruditus* (Acarina)

In his work on the embryology of the thelytokously parthenogenetic mite, *Cheyletus eruditus*, Hafiz[1] states: "The single nucleus of the ovum rises to the surface of the yolk and by dividing gives rise to a single layer of cells forming the blastoderm". He also states that just before oviposition 4–7 small nuclei may be found entering the cortical layer of cytoplasm and that blastoderm formation is completed 2 hr. after deposition. Thus he ascribes to this mite a form of superficial cleavage which is already proceeding at the time of oviposition, a view not confirmed by my observations.

I have found that in *C. eruditus* the egg at oviposition is undergoing first maturation division and that the first cleavage division is not completed until 2 hr. later. At the latter time, if the egg is submerged in water and viewed under × 50 binocular vision, a distinct line of demarcation may be seen across the transverse equator of the egg. The cytoplasm, in two equally divided masses, is seen in the centre of each 'cell' surrounded by the almost equally divided yolk. First cleavage division is therefore total, though it has not been ascertained if the yolk is completely divided. It seems likely that this division is no more than a superficial cleavage furrow, for it disappears with the completion, some 30 min. later, of the second mitotic division. With each successive division, the nuclei, surrounded by their

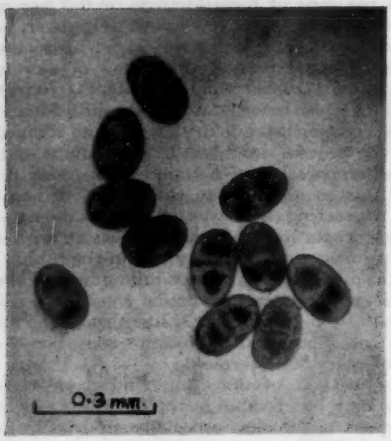

Fig. 1. Eggs of *C. eruditus* undergoing cleavage. Two eggs at bottom show the formation of the cleavage furrow which may be seen disappearing in the egg on the left as it nears completion of the second cleavage division

share of cytoplasm, move nearer the surface of the egg until, at the close of the fourth division, they are arranged on the periphery and from then onwards cleavage is superficial. Kramer[2] also noted that the first cleavage division of this mite is total, but he saw none of the intermediate stages between that and the completed blastoderm. Preliminary observations have shown that cleavage in *Cheyletus trouessarti* is similar to that in *C. eruditus*.

Cleavage which is at first total and later superficial has been termed 'combination cleavage' by Johannsen and Butt[3] and has previously been described for two other Trombidiforme mites, namely, *Pediculopsis graminum*[4,5] and *Pediculoides ventricosus*[6]. It is also found in the Collembola[7].

The main object of this communication is to direct attention to the mode of cleavage in *C. eruditus* and *C. trouessarti* so that subsequent speculation on the classification and phylogeny of the Acarina may not be misled by Hafiz's misinterpretation of his sections.

The eggs of this easily cultured mite provide suitable material for the laboratory demonstration of combination cleavage. The divisions may be observed and timed in the living egg when submerged in water and they may be preserved in 45 per cent acetic acid.

My observations will be described in detail in a larger work on the biology and cytology of the Cheyletids.

Thanks are due to the Bowden Entomological Trust of the University of Glasgow for financial aid and to Prof. A. D. Peacock, Queen's College, University of St. Andrews, for laboratory facilities and constant encouragement and advice.

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Physiology of the Hatching of Eggs of *Ascaris lumbricoides*

Several methods have been described for hatching eggs of *A. lumbricoides in vitro*[1,2]. These methods, however, give little indication of the processes which may occur *in vivo*. An understanding of physiological processes of hatching of the eggs has been sought by applying a form of the hypothesis of Rogers and Sommerville[3] which has been useful in examining the exsheathment of third-stage 'larvæ' of trichostrongyles. The modified hypothesis postulated that hatching of eggs would involve two processes: (*a*) stimulation by the host causing the egg contents to produce a hatching fluid and (*b*), the action of the hatching fluid on the egg shell.

(*a*) *The hatching stimulus.* Infective eggs, prepared by a method similar to that of Fairbairn[4], were stimulated to hatch in media containing sodium bicarbonate and a reducing agent under carbon dioxide in nitrogen. When bicarbonate – 5 per cent carbon dioxide buffer was used the rate of hatching (proportion of eggs hatched in 3 hr. at 38° C.) was greatest at *p*H 8 (Fig. 1). The rate usually increased when 10 per cent carbon dioxide was used in the buffer, but no eggs hatched in 100 per cent carbon dioxide. This inhibition was not due to high concentrations of sodium bicarbonate.

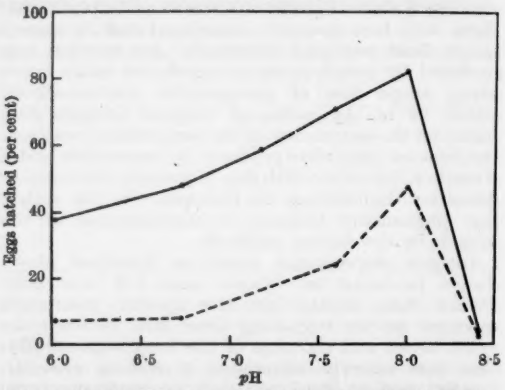

Fig. 1. Relationship between *p*H and proportion of eggs hatched. Sodium bicarbonate – 5 per cent carbon dioxide in nitrogen or sodium bicarbonate under nitrogen without carbon dioxide (*p*H 8·4) were used as buffers. The reducing agents were sodium dithionite, 0·02 *M* (upper curve), or cysteine, 0·02 *M* (lower curve)

The order of activity of reducing agents in promoting hatching was sodium dithionite > cysteine > ascorbic acid. All these substances showed optimal activity at 0·02–0·04 *M*. The addition to the basic medium of wetting agent ('Tween 80', 0·001 per cent or sodium taurocholate, 0·01 *M*), and salts (sodium chloride or potassium chloride up to 0·3 *M*) increased the rate of hatching somewhat. But without carbon dioxide and a reducing agent these substances had no effect.

Eggs which had been killed by heat or cold could not be stimulated to hatch. The degree of development also influenced the hatching of eggs (Table 1).

Four lots of eggs (*B*3, *B*6, *B*8 and *B*10) were used in these experiments. Under optimal conditions 80–90 per cent of *B*3 and *B*6 hatched in 3 hr.; *B*8 gave slightly lower results. But in lot *B*10 only 17 per cent hatched, even in 8 hr. The hatching of *B*8 and *B*10 *in vitro* was therefore compared with hatching in the intestines of mice 4 hr. after dosing.

Table 1. THE HATCHING OF EGGS AT DIFFERENT DEGREES OF DEVELOPMENT *in vitro**

Period of incubation at 30° C.	Proportion of eggs hatching in 2½ hr. at 38° C. (per cent)	
	*B*3	*B*8
17 days	1	1
18 days	2	3
19 days	78	7
20 days	82	77

* The medium contained 0·005 *M* sodium taurocholate, 0·0135 *M* sodium bicarbonate, 0·1 *M* sodium chloride and 0·02 *M* sodium dithionite under 5 per cent carbon dioxide in nitrogen.

In two experiments *in vivo* 62 and 72 per cent of *B*8 hatched, and 6 and 6 per cent of *B*10; that is, hatching *in vivo* paralleled hatching *in vitro*.

(*b*) *The hatching fluid.* This was prepared by gently shaking large amounts of eggs (about 5 gm.) in 20 ml. of bicarbonate – 5 per cent carbon dioxide buffer in nitrogen with 0·04 *M* sodium dithionite. Some salts which aid the survival of larvæ[5] were added, but wetting agents were omitted. The proportion of eggs (batch *B*8) which hatched in different experiments ranged from 50 to 70 per cent in 8 hr. at 38°. After eggs and larvæ were centrifuged off, the supernatant fluid was dialysed for 48 hr. against four changes of distilled water at 3°.

The action of control fluid (prepared without eggs) and hatching fluid on eggs was examined in 0·01 *M* acetate and phosphate buffers over the range *p*H 5–8 under air. The optimal *p*H was 7·3, at which about 40 per cent of eggs hatched at 3 hr. at 38°. Control fluid was inactive.

The addition of sodium chloride, potassium chloride, magnesium chloride and wetting agents in varied amounts had little effect. Control fluid or hatching fluid which had been heated to 80° for 10 min. was inactive.

As the egg shell of *A. lumbricoides* consists of an inner layer of lipid of low permeability, and outer layers containing chitin and protein, enzymes hydrolysing these substances were sought in the hatching fluid. Lipase activity was shown by electrometric titration with 0·01 *N* sodium hydroxide using 2 per cent tributyrin in water as substrate. The optimum was *p*H 7·5. This enzyme, it is presumed, would act as an esterase in hydrolysing lipids of the egg shell. Chitinase activity was shown with lobster chitin and empty egg shells as substrates. N-acetylglucosamine, identified by paper chromatography and spectrophotometry, was estimated by the method of Tracey[6]. Optimal activity with both substrates was obtained at *p*H 6. No protease could be found in hatching fluid with dialysed 10 per cent freeze-dried ox serum as substrate. But soluble amino-nitrogen, estimated by the method of Troll and Cannon[7], was released from empty egg shells in small amounts by hatching fluid. However, the optimum was about *p*H 6, and the chitinase may have caused the release of amino-nitrogen.

Five lots of hatching fluid were prepared; all were active and contained chitinase. Only two lots were examined for lipase. Both were active.

The hatching of eggs, when watched with a microscope, seemed to take place in two ways. Usually the inner membrane of the egg shell was seen to form a small bulge, apparently at a place where localized hydrolysis of the hard egg shell had occurred. The larva escaped from the egg by stretching and finally bursting through the bulge in the membrane. The empty egg shell retained its shape except that the hole, about the diameter of the larva, was marked by the protruding torn edge of the membrane. More rarely the hatching of eggs involved the hydrolysis of whole of the hard shell, leaving the larva enclosed on the vitelline membrane, which was distorted to follow the shape of the coiled larva. The larva finally emerged through a wide rupture of the membrane. Both forms of hatching were seen *in vitro* and in the small intestine of the mouse.

The results given here, though obtained with eggs which may have differed slightly from those laid by parasites within the host, suggest the nature of the physiological processes of hatching *in vivo*. (1) Dissolved gaseous carbon dioxide at low redox potentials stimulated the contents of infective eggs to produce a hatching fluid containing an esterase, chitinase, and possibly a protease. (2) The esterase altered the vitelline membrane of the eggs so that the chitinase, and possibly the protease, hydrolysed the hard shell either generally or in a restricted area. (3) Fracture of the membrane finally released the larva.

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Ring Formation in *Tilapia esculenta*

ONE of us (D. J. G.) is engaged in a statistical study of ring formation in the scales of *Tilapia esculenta* (Graham) from Lake Victoria. The rings on the scales of this fish are not so much formed by closer grouping of circuli as in temperate species, but rather consist of regions where the circuli are irregular or broken. Such rings are separated by regions where the circuli are regular and complete. Thus ring formation in this species would seem to be due not so much to a slowing of growth, but to continuance of growth in the scale under adverse conditions, resulting in imperfect calcification or formation of matrix.

Statistical evidence shows a correlation between the age of *Tilapia* and the number of scale rings, the rings themselves being associated with annual or biannual gonad maturation. It has been found[1] that ripe, running male, and brooding female *T. esculenta* are usually in a fasting condition, so that the correlation between ring formation and gonad maturation may be due to the lower condition of the fish in the fasting state. Brooding females are generally thin and flaccid compared to ripening or quiet specimens.

Since freshwater fish suffer a continual loss of minerals to their environment, and normally repair this deficiency with the minerals contained in their diet[3], a fasting fish might be expected to show defective calcification in skeleton and scales. Van Someren[3] has in fact shown that, in the Scottish salmon, fasting in the breeding migration up-river produces actual resorption of scale material.

It was thus decided to estimate the calcium content of scales and ovary in female *Tilapia* and of the serum in both sexes in varying states of gonad maturation, in the hope of discovering some more positive correlation between ring formation (assuming this to be due to impaired calcification) and the brooding fast. Several such estimations were performed, and the results are given in Tables 1, 2 and 3.

Table 1. Calcium Content (mgm. per cent) of Serum in Male and Female *Tilapia esculenta*

Male		Female	
Ripening	17, 17	Immature	32
Mature	17, 13, 15, 12	Ripening	31, 29, 23, 22, 25
Spent	15, 14	Mature	53, 53, 25
Spent quiet	16, 14, 16, 14	Spent brooding	26, 21, 16
		Spent quiet	17
		Spent starting	21, 20, 17·5, 17, 16

Table 2. Calcium Content (per cent dry weight) and Moisture Content (per cent fresh weight) in Ovaries of *Tilapia esculenta*

State	Calcium	Average	Moisture	Average
Immature	0·9, 1·9	1·4	64, 85, 86	78
Ripening	0·4, 0·2, 0·3	0·3	71, 64, 57, 58	60
Mature	0·3, 0·3	0·3	56, 53, 66, 53	55
Spent brooding	0·6, 0·7	0·65	81, 70, 73	75
Spent quiet	0·9	0·9	82, 84, 80	82

Table 3. Calcium Content (per cent dry weight) in Scales of Female *Tilapia esculenta*

State	Calcium	Average
Immature	24, 21	22·5
Ripening	23, 25, 24, 25	24·2
Mature	20, 18, 19	19·0
Spent brooding	16, 17, 17, 20, 22, 18, 21	18·7
Spent quiet	18, 20, 15, 21, 17·5	19·5
Spent starting	24	24·0

It can be seen that serum calcium-levels vary little in males, whereas in the female a marked rise in serum calcium occurs at full maturity, the calcium-level falling off in the brooding and quiet condition. Van Someren discovered a similar phenomenon in salmon and deduced from the evidence available that it was due to endocrine activity. Be this as it may, the results in Table 1 indicate a mobilization of calcium reserves in the fish at maturity.

Table 2 shows an apparent decline in calcium and moisture content in the ovary of ripening and mature female *T. esculenta*. This effect may be due partly to the rapid increase in lipid content of the ovary during maturation, which increases the dry weight of the tissue. The percentage rise in dry weight, however, is less than the percentage decrease in calcium.

The calcium content of the scales from female *T. esculenta* (Table 3) shows less marked changes with the state of the gonads, there being some overlap between the different stages of maturation. The average values, however, show a fall from ripening to mature, and from mature to brooding, condition.

Thus, from such results as are available, it seems that ripening and mature females mobilize calcium from their scales and gonad tissue and show a rise in serum calcium. In the fasting, brooding fish, this mobilization continues, but the continuous loss of calcium to the environment is not made up, and there is a subsequent fall in serum calcium. (This lowering of serum calcium may, of course, be due partly to the cessation of some parathyroid-like endocrine activity after spawning.) The formation of rings in the scales of these fish during breeding and brooding may thus reflect a temporary mineral deficiency.

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Biliverdin in the Eggs of *Nereis fucata*

Nereis fucata (Savigny) is a polychæte worm living in the gastropod shells carried by the hermit-crab *Eupagurus bernhardus* (L.) at Plymouth. The heteronereis or breeding stage found with hermit-crabs during late February was found to contain apparently ripe, blue eggs in the cœlom. The eggs were removed by slitting the body-wall of fresh worms, rinsed in sea water to remove hæmoglobin, and separated from cœlomic cells by repeated centrifuging. The pigments in the eggs were extracted into a methanol–sulphuric acid mixture (19 : 1), when a turquoise-blue solution was produced. A purple pigment remained in the eggs; the nature of this pigment is being investigated. The original blue colour of the eggs was apparently due to the mixture of the purple pigment and the turquoise extract. The turquoise solution was filtered through glass wool, diluted with an equal volume of water and shaken with chloroform. The chloroform layer became bluish-green. This was evaporated to dryness *in vacuo*, and the pigment redissolved in methanol. The absorption spectrum of this solution showed a sharp peak at 392 mμ and a broader peak at 650 mμ, with minimum absorption at 500 mμ. The addition of zinc acetate and iodine produced a brilliant pink fluorescence in ultra-violet light. When more iodine was added the fluorescence became green. The presence of biliverdin was confirmed by the production of a purple colour, with a spectral absorption maximum near 490 mμ, by the addition of concentrated nitric acid, and by the destruction of the blue-green pigment with concentrated sulphuric acid.

This appears to be the first time that biliverdin has been recorded in an egg, although it is known from the egg shells of certain birds[1], and a green pigment giving the Gmelin reaction is found in the eggs of the parasitic cirripede *Septosaccus*[2]. Biliverdin has been found in the body-wall of *Nereis diversicolor* O. F. Müller[3], but a re-examination of this species by us has revealed no biliverdin in the eggs. The pale yellow colour of *N. diversicolor* eggs may be due to minute amounts of carotenoids, but acetone extracts did not yield sufficient pigment for characterization. Similar quantities of *N. fucata* eggs yielded sufficient acetone-soluble pigment to be purified and identified as β-carotene. A further contrast is provided by the cœlomic cells, which are yellow

in *N. fucata* and green in *N. diversicolor*, contrasting markedly with the colours of the eggs. Further work on the pigments present in the cœlomic cells and eggs of these and various other polychætes is in progress.

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Effect of Ovariectomy, Œstrogen and Progesterone on the Activity of the Melanocytes in the Skin

The possible relationship between melanogenesis and the sex hormones has interested pathologists and physiologists for many years[1–5]. The present research is a histochemical investigation into the effect of ovariectomy, œstrogen and progesterone on the activity of the melanocytes in the skin of the guinea pig and is a continuation of the work reported previously on the influence of the male sex hormone on melanogenesis[6].

Eighteen mature virgin guinea pigs known to have a regular œstrous cycle were divided into three groups. Skin biopsies were taken from each animal of the first group at œstrus; ovariectomy was performed at the same operation. The skin specimens were removed from the ear, the anterior abdominal wall and from the sole of the foot; in addition, the right areola was excised. The animals were left for one month without treatment, after which they were killed, and a further series of skin specimens were removed from areas adjacent to those taken previously, and the left areola was excised. The animals of the second and third groups were also ovariectomized at œstrus, left for one month, and then skin biopsies were taken from the areas described previously. The animals of the second group were given 0·1 mgm. of œstradiol monobenzoate (Organon) intramuscularly once daily for five days a week for a period of four weeks; those of the third group were given 0·4 mgm. of progesterone (Organon) intramuscularly once daily for a similar period of four weeks. Following the hormone treatment the animals were killed and the second series of skin specimens were removed.

All the skin specimens were processed with the dihydroxyphenylalanine reagent after preliminary fixation and then both skin sheets and vertical sections were examined. The hormonal influence on the melanocytes was studied by assessing the number and size of the melanocytes and the amount and position of the melanin within the cells. The length and complexity of the dendritic processes were also noted, and an attempt was made to assess the amount of free melanin present.

Skin of ear, anterior abdominal wall and areola. After ovariectomy many of the melanocytes had a deformed appearance which varied from a slight shrinkage of the cell body with minor irregularity of the cell contour, to an advanced degree of cell-wall collapse with fragmented dendritic processes. In addition, the melanocytes showed varying degrees of lack of melanin. The amount of free melanin in the ear and anterior abdominal wall remained unchanged, but in the areola of four of the animals a definite reduction occurred. Both the melanin within and outside the melanocytes appeared lighter in colour. The melanocyte counts in the ear and anterior abdominal wall remained unchanged, but in the areola a definite reduction in the count occurred.

In the ovariectomized animals which received œstrogen the most marked effect produced was that the amount and depth of colour of the melanin both within and without the melanocytes was greatly increased. Many of the melanocytes were seen to be distended with melanin which completely obscured their nuclei. However, the gross deformity which occurred in some of the melanocytes as the result of ovariectomy was unaffected by the œstrogen therapy despite the increased amount of intracellular melanin. In the sections of the areola the large amount of free melanin present made the recognition of the individual melanocytes extremely difficult. The vertical sections showed that the increase in melanin occurred in all the layers of the epidermis. The melanocyte counts in the ear and anterior abdominal wall showed no definite changes, but in the areolæ of the two animals in which counting was possible the melanocytes were greatly increased in number.

In the ovariectomized animals which received progesterone, the size of the melanocytes and the length and complexity of the dendritic processes remained unchanged. The amount of melanin inside and outside the melanocytes was slightly increased in all areas. The melanocyte counts showed a small rise in the anterior abdominal wall, but the results in the ear and areola were inconsistent.

Sole of foot. Following ovariectomy no significant changes were observed. In the animals which were ovariectomized and received œstrogen a marked increase in amount and depth of colour of melanin occurred in all the layers of the epidermis. In the ovariectomized animals which received progesterone no significant changes resulted.

The above findings show that ovariectomy produces in varying degrees deformity of the melanocytes and inhibition of melanogenic activity. The administration of œstrogen to ovariectomized animals brings about a marked stimulation of melanogenesis, but it fails to restore the deformed melanocytes to their normal appearance. Progesterone was seen to have a similar effect on melanogenesis to that produced by œstrogen, but the changes were much less marked. The results indicate that the female sex hormones have a far more widespread effect on skin pigmentation than has hitherto been accepted. It is possible that this sex-linked control of melanocytes is related to the increase in growth-rate of malignant melanomas which occurs with the onset of puberty and during pregnancy.

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A Dominant Felting Lustre Mutant Fleece-type in the Australian Merino Sheep

Recently, our attention has been directed at occasional 'aberrant' fleece-types among Australian Merino sheep. This communication refers to a felting lustrous fleece-type of wh ch some twenty-two examples have so far been located.

Evidence from flocks in which this fleece-type occurred, and the breeding record of one mutant ewe indicated a single dominant gene. Results from mating a mutant ram to forty-one normal ewes (Table 1) confirmed this.

Table 1. Segregations from Matings of Normal and Felting Lustre Mutant Fleece-types in Merino Sheep

Mating	*n*	Segregation	
		Normals	Mutants
Mutant ♀ × Normal ♂	1	1	1
Normal ♀ × Mutant ♂	41	22	19

The phenotype is as follows: adult fleeces have a lustrous light yellow appearance similar to that of sheep of lustre-wool breeds (Lincoln, Leicester). Scouring removes the yellow colour but the cleaned fibres retain a definite lustre by comparison with normal Merino wools. Individual fibres and staples both lack the characteristic crimping of Merino wool though some fleeces show 1–4 shallow waves per inch of staple. The birth-coat of these mutants also has a cream colour, though lustre and absence of crimping are most characteristic. Birth-coat fibres are non-medullated and are not shed.

The lack of crimping and the lustre of adult fleeces is typical of wool of 40–46's count. However, this wool is finer than that grown by similarly bred sheep under the same conditions (Table 2). Moreover, the frequency distribution curves of fibre diameters are closely similar for mutant and normal wools and neither the lustre nor the lack of crimp is due to a proportion of coarse lustrous fibres. Growth-rates of staple-length and fibre-length are about normal. Estimates of wool production under pen conditions and on high protein rations fed *ad libitum* show that clean wool weight per unit area of skin is low, being approximately two-thirds of normal.

Table 2. Range of Values for Fleece Characters of Five Felting Mutant Fleece-types compared with Normal Fleece-types of same Strain (Pen Conditions, *ad libitum* Feeding)

	Felting mutant	Normal
Crimps/in.	0–3	12–18
Fibre diameter (μ)	18–22	20–24
Fibre growth-rate (mm./day)	0·36–0·38	0·36–0·40
Wool production (mgm./cm.²/day)	0·3–0·6	1·0–1·2
Total density (fibres/mm.²)	25–45	50–90
S/P fibre ratio	12·0–17·5	18·0–25·0
Primary density (primaries/mm.²)	1·4–2·0	2·0–4·0

Histological observations demonstrate reductions in the ratio of secondary to primary follicles, in total fibre density, and in primary fibre density.

Methylene blue staining shows that this almost crimpless type of Merino wool lacks the bilateral separation into ortho- and para-cortex characteristic of well-crimped wool fibres[1]. The adolescent mutant fleece exhibits three separate phases of fibre growth (Fig. 1). The pre-natally grown birth-coat portion is quite straight, and neither this tip portion nor the equally crimpless butt portion of the individual fibres shows any lateral differentiation of ortho- and para-cortex. The crimped portion of these same fibres, presumably grown during the period of suckling, shows hemi-lateral differentiation of ortho- and para-cortex. Three such adolescent fleeces gave similar results which are in agreement with the present view that crimping of wool fibres is associated in some as yet unspecified way with the histochemical differences and/or the relative disposition of ortho- and para-cortical fractions. This fleece-type therefore provides a new tool for investigating the underlying mechanisms of crimp formation in wool fibres.

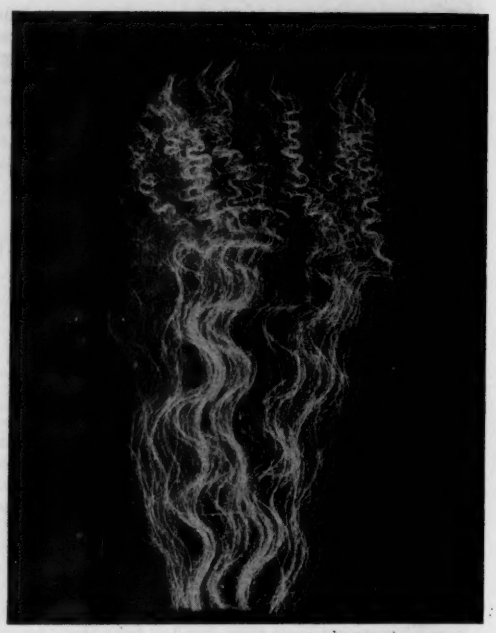

Fig. 1. Wool staple showing pre-natally grown birth-coat tip, early post-natal growth and fibre growth after three months

In the field this type of fleece is almost invariably matted on the sheep, causing some discomfort. Sheep so far located have been below their flock average in body-weight. They are also entirely devoid of skin folds or wrinkles, even after 12 months of high-level feeding, though almost all other Merino sheep show some skin wrinkling. Cotting of the unprotected fleece will commence when the fibres are only ¼ in. in length.

Felting tests (Pressley, T. A., personal communication) have shown that this wool felts (shrinkage to 50 per cent of initial area of standard sample) about seven times faster than normal and copper-deficient Merino wools of similar mean diameter. Maximum felting occurs as quickly as in carrotted rabbit fur and more than twice as quickly as in normal, hatter's and copper-deficient Merino wools. Microscopical examination revealed no clear-cut differences between mutant and normal Merino fibres in the relative prominence of scale edges or of their pattern which might account for the lustre or felting capacity of these fibres.

Fleece-mutants are unique material for genetic and physiological studies of fleece structure and wool production and also provide material for textile research. In this case, fibre structure, felting be-

haviour, and surface properties are being studied as well as performance during commercial processes.

This communication indicates only the salient features of a felting lustrous mutant Merino fleece-type and its research and commercial potential. Detailed data will be published elsewhere.

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Williamson's Theory of Interspecific Competition

In a recent communication[1], Williamson sets out to explore the results of competition between two species of animals living together in the same place. He defines a controlling factor and builds his model on this definition. He says "a car needs more steering on a rough road than on a smooth one" and argues by analogy that a controlling factor is more important in a stochastic than in a deterministic model. Steering is only necessary on any road because the driver wishes to stay alive and reach his destination. Does Williamson imply that controlling factors are necessary because the mathematician wishes to keep his population extant and directed towards his goal? It may be proper for a mathematician to have such a wish but it is scarcely relevant to the study of natural populations since extinction is the usual fate of most populations and probably the inevitable fate of all[2].

In order to proceed with his model, Williamson makes five assumptions which delimit the meanings of the symbols he is to use in his mathematics. He then proceeds to derive his equations (8) and (9) which describe the course of competition between two species. He shows that under the conditions specified in these two equations the "two species are in stable equilibrium although there is but a single controlling factor which acts on both". To this point we can perhaps go with Williamson (although, as has been pointed out elsewhere[2], there are grave difficulties associated with his concept of environment); but in the next sentence he makes the following statement: An example of this would occur if two species of snail were controlled by a single species of bird, and if the bird tended to prefer whichever snail was the commoner both species of snail could persist". This statement can be read only in the context of Williamson's five assumptions. In this context its proper meaning should be expressed somewhat as follows: An example of this would occur if two species of snail, the individuals of each of which were all of the same sex, stayed always at the same age and were genetically identical, and which in reproducing gave rise instantly to mature adults identical with themselves, lived in a place in which the topography was quite uniform, where food, which had the property of being always replaced just as fast as it was eaten, was uniformly distributed and did not vary in quality, where the seasons were identical and where the time of day and the weather did not change. If these two species were preyed upon by a single species of bird (the individuals of which had characteristics similar to the snails) and if the bird tended to prefer whichever was the commoner snail, both species of snail could persist, provided that no animals entered or left the area and the numbers of snails always remained large enough for deterministic rather than stochastic equations to be used and for the numbers to be treated as continuous variables.

What must be the courage of the mathematician who feels free to make the dizzy leap from his abstract symbols to the real snails and birds of this world? What heavy chains of empiricism must we wear who fear to follow him in his flight?

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I am glad that Drs. Andrewartha and Browning have been able to go some way with me. I hope that the following remarks will help them to travel further. The example of the car was used as an analogy, not as an argument. Any population that persists for more than a few generations must be controlled: any car that progresses more than a few yards without accident must be steered. To say that no age distinctions are recognized does not mean that all individuals are of the same age. It means that the probability of an event, such as being eaten, happening to an individual is independent of that individual's age. My other assumptions should be interpreted in the same sort of way. I made no assumptions about food; the only one needed is that there is enough of it. Land snails are usually hermaphrodite and so all of the same sex.

My equations may perhaps be compared to anatomical diagrams. They attempt to represent what I think are the important points in population dynamics, in the same way that a diagram brings out the important points of anatomy. Neither is intended to be a complete representation.

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Effect of Photoperiod on the Oxygen Consumption of Two Species of Intertidal Crabs

Light as an environmental parameter has been given slight consideration with respect to its effect on rate functions of intertidal marine invertebrates. Prosser[1] has mentioned a few examples where light has been considered as a limiting factor. Most of these examples have concerned vertebrates. Recently, Hoar[2] demonstrated that different light periods affected thermal resistance in goldfish. Short-day (8 hr.) photoperiod fish were more resistant to cold than long-day (16 hr.) ones. The reverse was true for heat adaptation.

Measurements of oxygen consumption of two local intertidal species, *Hemigrapsus nudus* and *Hemigrapsus oregonensis* have been made under different conditions of temperature and salinity. These results have been recorded throughout the year on animals maintained for twenty-four hours at temperatures and salinities which approximated seasonal conditions (rate/temperature experiments). Other experiments have involved the acclimation of both winter and

summer populations of these two species to various combinations of temperature and salinity over a period of several weeks. Oxygen consumption has been measured for each of the following four acclimation temperatures, 5°, 10°, 15° and 20° C., over a range of acclimation salinities (25–125 per cent sea water, at 25 per cent intervals). The respiratory response differed greatly, depending upon the combination of temperature and salinity used (low temperature, low salinity; low temperature, high salinity; high temperature, low salinity; high temperature, high salinity). Detailed results of these experiments are to be reported elsewhere[2].

In order to determine the effect light has on oxygen consumption, it was necessary to know the nature of the response crabs showed to temperature and salinity, as single factors and in combination. This has been determined previously as noted in the above experiments. Secondly, it was necessary to select certain temperature and salinity relations in order to reduce the number of possible combinations when a third environmental factor was introduced. The following experimental temperature and salinity combinations have been chosen: 5° C. and 70 per cent sea water—winter conditions; 5° C. and 35 per cent sea water—spring conditions; 15° C. and 35 per cent sea water—summer conditions; 15° C. and 70 per cent sea water—autumn conditions. These selections were made because they represent approximate seasonal field conditions. Lower spring intertidal salinities have been recorded, but 35 per cent sea water (based on 31·88‰ as 100 per cent) lies well within the seasonal range.

Here, only summer conditions are reported. Male crabs of both species, from summer (warm-adapted) populations were used. For each temperature–salinity condition mentioned above, three groups, about thirty-five crabs per group, were placed in plastic containers. Animals remained totally immersed in sea water of the appropriate dilution and the containers were kept in temperature- (±1·0° C.) and light-controlled refrigerators. The first group received 8 hr. daily illumination (30 foot-candles) alternating with 16 hr. darkness; the second group received 16 hr. daily illumination (same intensity) alternating with 8 hr. darkness; the third group (control) was kept in total darkness. The first situation corresponded to the hours of sunlight in winter, and the second, to the sunlight period of summer. At the end of one, two and in some experiments three weeks, oxygen consumption was measured with Wennesland–Scholander microrespirometers[3]. In all experiments oxygen consumption was measured at 15° C. (±0·1°). Sufficient time was allowed for animals to be adjusted to 15° C. when transferred from acclimation temperatures to the respirometer water bath. Upon completion of each experiment, animals were weighed and returned to the temperature-controlled and light-controlled refrigerators. Crabs were not fed during the course of these experiments.

Fig. 1 illustrates the effect of light on the oxygen consumption of the summer population of *Hemigrapsus oregonensis* kept at a temperature and salinity (15° C.; 35 per cent sea water) approximating to summer field conditions. Under these conditions, short daily periods of illumination (8 hr.) resulted in increased oxygen consumption when compared with either the long photoperiod (16 hr.) or the control group (dark). If 2·0 gm. crabs are compared it is seen that oxygen consumption has increased in the 8 hr. photoperiod group by 55 per cent (84 mm.³ oxygen/gm./hr.; 54 mm.³ oxygen/gm./hr.) over that of the 16 hr. photoperiod or the control. Similar values for the 16 hr. group and the control group are evident. Other experiments with the same three light conditions but different temperature and salinity combinations, demonstrate the persistence of this similarity between long photoperiods and total darkness.

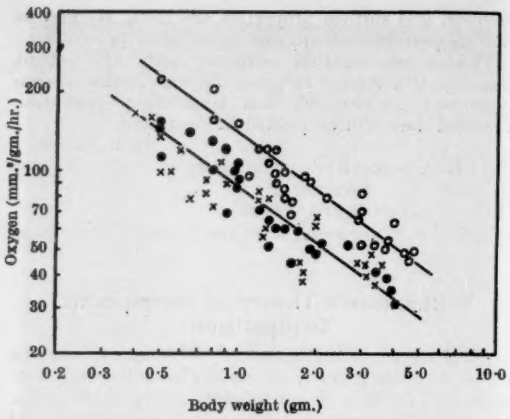

Fig. 1. Weight-specific oxygen consumption as a function of weight in summer *Hemigrapsus oregonensis* measured at 15° C. Animals were kept at 15° C. and 35 per cent sea water for two weeks. Measurements were taken at the end of each week. Each point represents an individual. ○, Animals exposed to 8-hr. daily illumination; ●, animals exposed to 16-hr. daily illumination; ×, animals kept in total darkness (controls). Regression lines are fitted by eye

A similar effect of the three light conditions on oxygen consumption of a summer population of *Hemigrapsus nudus* has been determined, under the same experimental conditions (15° C.; 35 per cent sea water) as *Hemigrapsus oregonensis*. Again, weight-specific oxygen consumption is highest in the 8 hr. photoperiod group. The increase for 2·0 gm. animals is about 36 per cent (87 mm.³ oxygen/gm./hr.; 64 mm.³ oxygen/gm./hr.). The difference is not as great but the trend is consistent. Again, there is a similarity of values for the 16 hr. photoperiod and the control groups.

In Fig. 1 measurements for the first and second week have been combined, since they are not significantly different. Further, a regression line has been drawn for the 16 hr. group but not for the control. These two groups differ only slightly and, for clarity, these data have been presented in this manner.

These results demonstrate that illumination affects significantly weight-specific oxygen consumption in these two species of crabs, maintained under constant temperature (15° C.) and salinity (35 per cent). Increase in weight-specific oxygen consumption in the 8 hr. photoperiod group suggests that summer crabs, when exposed to winter light conditions, adjust their oxygen consumption to winter conditions. These crabs have been exposed to winter light duration prematurely, relative to field conditions. The adaptive value of a mechanism such as this may prepare the animal to operate under low temperature (winter conditions). It will be necessary to compare summer animals at summer temperature and salinity with winter animals at winter conditions, both groups exposed to 8-hr. and 16-hr. illumination, before the effect of light on metabolic activity is understood.

Such experiments are now in progress. Evidence suggests that the light effect is dependent, to some extent, on temperature and salinity relations. Summer animals, either 8- or 16-hr. groups, respond differently when maintained under different combinations of temperature and salinity. The tendency is for 8-hr. groups to increase the percentage difference of weight-specific oxygen consumption, when compared with 16-hr. and control groups, as temperature increases and salinity decreases.

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Effect of Stress and Cortisone on the Cytomorphology of Pituitary Grafts in Rats

IN the course of previous investigations[1-3] it was demonstrated that following stress (administration of formalin, intensive dehydration) the number of basophil cells in the adenohypophysis of rats increased considerably. For the development of this phenomenon the presence of the adrenal gland is needed: thus if formalin stress is applied in adrenalectomized animals, basophil hyperplasia fails to develop. The importance of the adrenal cortex is also supported by the fact that cortisone treatment also increases the number of the basophils[4].

Recent work suggests that the hypothalamus plays an important part in the regulation of the function of the adenohypophysis[5]. It was of interest, therefore, to examine whether stress or cortisone can influence the cytomorphological picture of the adenohypophysis if its direct connexion with the hypothalamus is interrupted.

To elucidate this problem, the adenohypophysis of rats was transplanted into the anterior chamber of the eye. These experimental conditions seemed more suitable than section of the stalk, as the transplanted pituitary vascularizes well, whereas after section of the stalk disorders of the blood supply—occasionally leading to necrosis and fibrosis—may occur[6].

The experiments were carried out on fifty female albino rats each weighing 150–200 gm., kept on a mixed diet. The hypophysectomy was performed under ether anæsthesia by the usual parapharingeal approach, and the adenohypophysis was transplanted into the anterior chamber of the left eye, the neurohypophysis being discarded. The experiments were started one month after the operation. 10 mgm. cortisone ('Adreson', Organon) was administered subcutaneously to each of ten rats every day for eight days. Ten other rats were treated with formalin (0·5 ml. of 2 per cent formalin administered subcutaneously every day for one week, and twice daily after the eighth day). Thirty rats were used as controls. The animals treated with cortisone were killed on the eighth day, whereas the administration of formalin was continued until the animals died. In addition, ten untreated non-operated controls and two groups of ten non-operated animals, treated on identical conditions with cortisone and formalin respectively, were examined histologically. The hypophyses were fixed in Susa solution and embedded in paraffin. The serial sections were stained by Goldberg and Chaikoff's method[7].

Complete disappearance of the basophil cells could be observed in the pituitary grafts of the untreated hypophysectomized rats. The number of the eosinophils also decreased considerably, so that only a few markedly degranulated eosinophil cells could be found. Chromophobes predominated. These findings are in agreement with the results of other authors[8]. The hypophyses vascularized well, and among the cell cords broad sinusoids containing blood were seen. Necrosis could not be detected.

Administration of formalin did not alter the cytomorphological picture of the pituitary grafts. In normal rats an intensive basophil hyperplasia develops in the adenohypophysis after formalin treatment, whereas in the implanted animals no basophils could be observed.

The basophil cells reappeared in the pituitary grafts of the animals treated with cortisone. In normal rats cortisone administration resulted in an increase of basophils. The cells became hypertrophied, the basophil granules of their cytoplasm became homogeneous, stained deep blue and in some places resembled Crooke cells. In the grafts some of the basophils were homogeneous, the granules condensed perinuclearly and in other places became hypertrophied, and finely degranulated basophils could be observed.

Our investigations show that for the development of basophil hyperplasia due to formalin stress direct connexion between the adenohypophysis and the hypothalamus is necessary. On the other hand, the effect of cortisone on the cytomorphology of the adenohypophysis does not occur through the hypothalamus but is exerted directly on the basophil cells of the pituitary.

In the course of retransplantation of the grafted, degranulated and chromophobic pituitary under the median eminence, Nikitovitch-Winer and Everett[9] observed the reappearance of the basophils. This morphological change occurred simultaneously with the restoration of the function of the adenohypophysis. Our investigations point to the fact that the reappearance of the basophils after administration of cortisone occurs in the case of pituitary grafts also. The alternative view that these cytomorphological changes may be of degenerative or regressive nature, or that they may result from the alteration of the functional state of the transplanted pituitary, must now be analysed.

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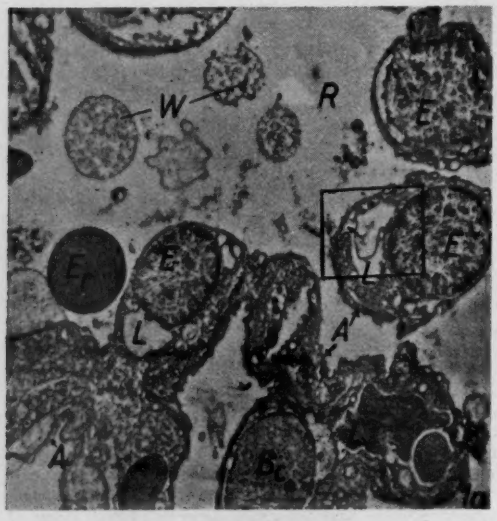
Alterations in the Ultrastructure of the Blood–Air Barrier in the Mouse Lung after Inhalation of Colloidal Gold Particles

Many problems concerning the morphology of lung-tissue, revealed by optical microscopy, have been solved with the electron microscope[1–3]. But the origin of the alveolar lining has not been elucidated so far. To throw some light on this question we have studied, by means of the electron microscope, the changes in the capillaries and lung alveoles of mice after inhalation of colloidal gold aerosols. We wished, first, to trace the heavy particles of gold in the phagocyting cells; secondly, to stimulate all cells activated by powerful irritation.

Young white mice were exposed for 20 min. to an aerosol of oleo-chrysobiose (Union Chimique Belge), and killed 20 hr. afterwards. The lungs were perfused with osmium tetroxide (Palade), embedded in methacrylate, and sections were cut with Sjöstrand's ultra-microtome. These were examined in a Philips *EM* 100 microscope.



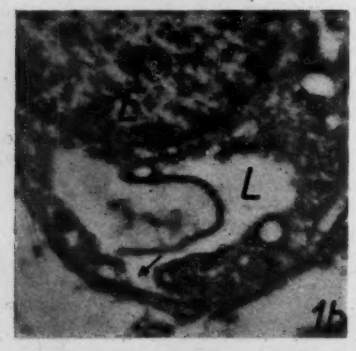


Fig. 1. (*a*) Section through mouse lung tissue after inhalation of aerosol. The capillary lumen (*L*) is either much reduced (middle right) or completely absent (upper right corner). The endothelial cells (*E*) are swollen, and their nuclei puffed. Connective tissue cells (*Bc*) and nuclei are also enlarged. The alveoles are lined by a thin layer of alveolar cytoplasm (*A*). (*b*) Enlargement of the middle right capillary of Fig. 1*a*. Narrow lumen (*L*), swollen endothelial cytoplasm with a wide open endothelial junction (→)

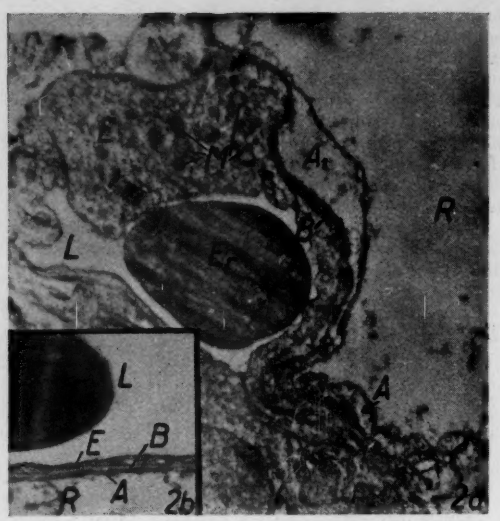


Fig. 2. (*a*) Blood–air barrier in mouse lung after inhalation of colloidal gold. Narrow capillary lumen (*L*), showing a red blood cell (*Er*) in close contact with the swollen endothelial lining (*E*). Mitochondrial profiles (*M*) can be recognized in the endothelial cytoplasm. The alveolar lining shows only localized swellings (*A*1). (*b*) Blood–air barrier in untreated control mouse lung, showing the normal thickness of the endothelial cytoplasm (*E*) and the alveolar lining (*A*)

In the vast majority of preparations, the capillary lumen is either much reduced or completely absent (Figs. 1*a*, *b*). The endothelial cells are swollen, their nuclei puffed, and the thin protoplasmic layer around the lumen thickened. Between the indentations, red blood cells are trapped and even crushed. Endothelial junctions appear wide open because of the distortion of the cells (Fig. 1*b*).

Connective tissue spaces are also considerably enlarged, due to great swelling of their cells. The nuclei of the latter are decidedly enlarged and show one or two nucleoli. Their cytoplasm is often filled with mitochondria. These enlarged connective tissue cells can scarcely be distinguished from the swollen endothelial cells, especially since at many places the basement membrane, normally separating the endothelium from the connective tissue space, is absent.

In marked contrast, the alveolar lining shows scarcely any alterations: only occasional, localized protoplasmic swellings. The basement membrane between this layer and the connective tissue space is unaffected.

In the lumen of the alveoles intact leucocytes are found; also irregularly shaped histiocytes, filled with mitochondria, closely resembling the swollen connective tissue cells and unaltered red blood cells. Contrary to our expectation, no slide showed any trace of colloidal gold particles.

Policard, Collet and Noufflard[4] examined lungs of rats after introducing either minute silica particles or tubercle bacilli into the trachea. They noted the thickening of the endothelial cells, the narrowing of the lumen of the capillaries and the disappearance of the basement membrane between the endothelium and the connective tissue space. But they first saw a thickening of the alveolar lining. Contrary to this, our aerosols with colloidal gold induced in the lungs

of white mice a simultaneous reaction of the endothelial layer and of the connective tissue of the septa, while the alveolar lining scarcely reacted at all. We believe that this fusion of the first two layers is a strong indication of their common origin.

Other evidence points in the same direction. In our contention, any infection or other irritation induces simultaneous morphological and dynamic transformations in the connective tissue and in the endothelial cells. Their appearance shows a regression towards a more primitive state, common to both kinds of cells. But this regression makes possible far more useful defence reactions: such as local phagocytosis or migration towards the threatened area followed by phagocytosis.

Regression is well known as a typical reaction of the organic world. But what may perhaps sound a little more unusual is the idea that this property of all living things may provide an indirect method for studying the histogenesis of certain cells. Besides comparative histology and embryology, it may be possible to verify how morphological differences and specialization of living cells are affected by experimental irritative action. Whenever the tissue reacts with a true regression as a mechanism of mobilization and defence, it becomes possible to watch a previous stage of development which may prove to belong to several tissues, which, in normal circumstances, appear to differ widely.

Our experimental study of lung tissue from white adult mice shows that endothelial and connective tissue cells may re-acquire both the appearance and properties of fibroblasts. This is good evidence for their common mesenchymatous origin. The negative evidence of the very weak reaction of the alveolar lining towards the same experimental irritation is in itself not devoid of interest: indeed, we believe rather that it speaks in favour of the epithelial origin of alveolar cells.

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Antibody Production by Single Cells

Fagreus[1] and others[2,3] have shown that certain tissues from pre-sensitized animals can form antibody *in vitro*. This communication describes a technique whereby antibody production by single cells isolated in microdroplets can be detected. The technique is based on specific immobilization of *Salmonella* serotypes by anti-flagellar antibody. It was observed that single cells from a rat, simultaneously stimulated with two antigens, formed detectable amounts of one or the other antibody.

Two monophasic *Salmonellae* were used: *S. adelaide*, flagellar antigen $H_1 g$, and *S. typhi*, $H_1 d$. They were maintained at maximum motility by frequent passages through a semi-solid nutrient gelatin agar medium[4]. A formalinized broth culture containing about 10^9 organisms per ml. was used as the antigen. Adult Wistar rats were injected with 0·25 ml. of a mixture of equal parts of both antigens into both hind foot-pads. Usually the animals were given three pairs of injections at three weekly intervals. Three days after the tertiary injections, they were killed by exsanguination under anæsthesia. Both popliteal lymph nodes were removed, pooled, and processed[6] to give dispersed cell suspensions in Earle's saline buffered to *p*H 7·0 with *tris*, and supplemented with 20 per cent normal rat serum. The cells were sedimented by gentle centrifugation, and washed three times to remove free soluble antibody. Single cells were then isolated in microdroplets by a simple modification[4,5] of de Fonbrune's oil chamber method[7]. This consisted essentially of depositing tiny droplets (volume 10^{-7}–10^{-6} ml.) on the surface of a coverslip and immersing them in paraffin oil. The coverslip was then inverted over a chamber filled with oil. The easiest method for preparing droplets containing one cell was to dispense a large number of droplets by free-hand manipulation from a suspension containing 1 : 400 by volume of lymph node cells. These droplets contained from nought to six cells; each droplet was later recorded for its cell content. Larger droplets containing up to 100 cells could also be prepared. Alternatively, droplets containing exactly one cell each could be prepared by micromanipulation, but this was more tedious, due to the adhesion of the cells to the micropipette. The oil chamber was then incubated at 37° C. for 4 hr. At the end of this time, the chamber was placed on a microscope and the droplets surveyed at one hundred-fold magnification, dark ground. With a micropipette controlled by de Fonbrune micromanipulator, about ten bacteria were introduced into each droplet. Half the droplets were inoculated with *S. adelaide*, and the other half with *S. typhi*. After twenty minutes at room temperature, the droplets were observed for motility of the organisms. Total loss of motility of all the organisms was recorded as 'inhibition'. If even one organism in the droplet remained motile, this was recorded as 'no inhibition'. For control purposes, the suspending medium, the final supernatant from the washings, and the whole cell suspension prior to incubation were all shown to be free of inhibitory activity. Droplets prepared from the final cell suspension but containing no cells were also scored and found to lack inhibitory activity. Cells from several untreated rats were tested and these failed to elaborate a factor inhibiting the motility of the bacteria. Antisera against each serotype showed negligible cross-reaction with the other.

A proportion of the cells from immunized animals developed a factor immobilizing the test bacteria, and this was presumed to be antibody. All droplets containing single cells which were seen to immobilize the first serotype were then inoculated with about ten organisms from the second. After a further twenty minutes at room temperature, they were again observed for motility. The results of a typical experiment are recorded in Table 1. They indicate that none of the single cells was able to immobilize the organisms of both strains. To date 456 single cells have been tested for antibody production, 228 against each of the two organisms. Out of these, 33 were active against *S. adelaide* and 29 against *S. typhi*, but none of the 62 immobilized both strains.

Table 1. Antibody Production by Isolated Cells

No. of cells in drop	No. of drops inhibitory	No. of drops tested
First tested versus *S. adelaide*		
1	6*	39
2	5	25
3	7	24
4	6	21
5	6	10
6–10	17	33
First tested versus *S. typhi*		
1	3*	18
2	6	26
3	0	14
4	3	14
5	1	8
6–10	22	42

Lymph node cells from rats presensitized to *S. adelaide* plus *S. typhi* were dispensed in micro droplets and incubated for 4 hr. They were then tested by the introduction of motile bacteria.
* These droplets were also tested for activity against the alternative serotype and were negative.

These results imply that when an animal is stimulated with two contrasting antigens, individual cells tend to form one species of antibody. We cannot exclude a residual production of other antibodies at lower rates. The experiments were provoked by current hypotheses on the role of clonal individuation in antibody formation[6,7], with which they are consistent so far as they go. However, further studies will be needed to determine whether the assortment of antibody-forming phenotypes reflects a genotypic restriction or whether it is more akin to such phenotypic effects as interference between related viruses, or diauxie and competition in enzyme formation.

We are indebted to Sir Macfarlane Burnet for his interest, encouragement and hospitality. This work was aided by a grant from the National Health and Medical Research Council, Canberra, Australia. It was done as part fulfilment of the requirements for the degree of doctor of philosophy in the University of Melbourne (G. J. V. N.).

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Similar Effects of Blue and Infra-Red Radiation on Light-sensitive Seeds

Evidence that blue spectral regions affect the germination of light-sensitive seeds has existed for some years, and has recently been confirmed for both light-inhibited[1] and light-promoted seeds[2,3]. Borthwick *et al.*[2] obtained both promotion and inhibition of germination of lettuce seed by blue radiation, depending on the duration of the period the seeds had been allowed to imbibe water prior to irradiation. Evenari *et al.*[3] have also reported both stimulation and inhibition by blue light, depending on the imbibition period. It is well known that infra-red is also inhibitory to the germination of lettuce seed and that there is a specific interaction between infra-red and red radiation, the effects of red being reversible by infra-red and *vice versa*. A similar specific interaction between red and blue light has apparently not previously been reported, although Flint and McAlister[4] showed that a long exposure of lettuce seed to blue spectral regions nullifies the promoting effect of a previous exposure to red. In the following experiments it was shown that the action of blue is effectively similar to that of infra-red.

In these experiments the primary light sources consisted of (1) red fluorescent tubes in conjunction with red 'Perspex' (*R* 400) and (2) blue fluorescent tubes in conjunction with blue 'Perspex' (*B* 705) together with a 1 cm. screen of *M*/3 copper chloride, a combination which transmits the band 400–520 mμ. The experiments were carried out at 25–26° C. Preliminary experiments indicated that with irradiation periods of 30 min. or longer, blue light is inhibitory when the imbibition period exceeds about 12 hr., and hence in the following experiments imbibition periods of about 24 hr. were used.

The seeds were first exposed to 1½ min. of red light at an intensity of 100 μW./cm.², followed by various periods of blue (at the same intensity) ranging from ½ to 4 hr. Some inhibition of germination was obtained with periods of 1–2 hr., but much more effective inhibition was obtained with 4 hr. of blue. In a further experiment, using 1½ min. of red and 4 hr. of blue, the effects of a succession of irradiations with red and blue were investigated. It was found that repeated photo-reversal can be obtained (Table 1) and that the response of the seeds is determined by the nature of the last irradiation, as in the interaction between red and infra-red. The energy required to produce 50 per cent inhibition of germination by blue is about thirty times greater than for infra-red, however. By using a series of Schott interference filters with peak transmissions at 405, 452, 483 and 496 mμ respectively, in conjunction with a 1,000-watt projector lamp, maximum inhibition was found to occur at 452 mμ.

Table 1. Lettuce, var. Grand Rapids. Photoreversal of Promotion and Inhibition of Germination by Red and Blue

Irradiation	Germination
R	77·7
R—*B*	33·0
B—*R*	75·5
R—*B*—*R*	86·1
R—*B*—*R*—*B*	49·0
Dark control	29·0

R, 1½ min. red at 100 μW./cm.² from fluorescent source. *B*, 4 hr. blue at 100 μW./cm.² from fluorescent source. Treatments were commenced 26 hr. after sowing.

Both blue and infra-red appear to be effective also with the light-inhibited seed of *Nemophila insignis*. In previous experiments reported by us[1], it was shown that *Nemophila* seed is inhibited by blue light and we have since found that maximum effectiveness occurs in the region of 450 mμ. There is a further inhibitory band in the infra-red, with strong inhibition in the region of 710 mμ and less at 760 mμ. Our previous failure to obtain inhibition from an infra-red source transmitting wave-lengths longer than 730 mμ appears to have been due to the employment of too low an intensity at less effective spectral regions. The inhibition obtained when using red fluorescent tubes, on the other hand, appears to have been due to the content of near infra-red from this source.

Thus, in the seed of both lettuce and *Nemophila*, inhibitory effects are produced by infra-red and blue, and in lettuce seed these two spectral regions show similar interaction with red. These observations suggest that either the photoreceptor involved in the infra-red effects has an absorption region also in the blue, or, alternatively, that some distinct blue absorbing photoreceptor is capable of energy transfer to the infra-red receptor.

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Saskatoon, Canada.
March 20,

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[2] Borthwick, H. A., Hendericks, S. B., Parker, M. W., Toole, E. H., and Toole, V. K., *Proc. U.S. Nat. Acad. Sci.*, **38**, 662 (1952).
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Artificial Stimulation of Rainfall in East Africa by Means of Rockets

Experiments on artificial stimulation of rainfall have been carried out by the East African Meteorological Department since 1950. The earliest experiments at Kongwa, Tanganyika, in 1951, using silver iodide, were inconclusive, but the evidence suggested that this substance was not efficient as a seeding agent in East Africa[1]. Later, experiments using the balloon-bomb technique and sodium chloride were carried out at Kongwa in 1952, Amboseli, Kenya, in 1953 and Dodoma, Tanganyika, in 1954. In the 1952 Kongwa experiment there was an increase in total rainfall down-wind from the seeding position and in both the Amboseli and Dodoma experiments it was observed that cloud-seeding usually produced light rain[2].

In the latest series of experiments during November–December 1956 at Tabora, Tanganyika, rockets were used for cloud-seeding. In conjunction with the Ministry of Supply and the Admiralty, 2-in. naval flare rockets were modified to carry a charge of about 1¼ lb. of finely ground, desiccated sodium chloride in the head. The rockets could be fired at any chosen cloud and were fused so that the sodium chloride was well dispersed in the cloud during the passage of the rocket. The cloud-seeding took place over the Tabora reservoir catchment area and a network of 30 rain-gauges was laid down in the saucer-shaped region, which covered an area of about 20 square miles. In the absence of a control area, the experiment was conducted on a randomized basis; the decision as to whether cloud conditions were suitable for seeding was made first and sealed instructions prepared by a random process were then consulted to determine whether seeding should take place or not. There were approximately the same number of seeding and non-seeding days and, so far as could be determined, weather conditions were suitable for cloud-seeding during both periods.

Some of the results appear to be significant. A comparison between total rainfall on seeding and non-seeding days showed that the rainfall in the catchment area immediately down-wind of the rocket-launching site tended to be a minimum during the non-seeding period and a maximum during the seeding period, the difference between the two periods being of the order of 2 to 3 inches. The time lapse between seeding and the appearance of rain varied considerably with an average of 9 minutes, which is much shorter than the times estimated by Ludlam[3] and Bowen[4]. A possible explanation of the earlier appearance of rain may be the instantaneous and wide dispersal of the sodium chloride and the increase of turbulence within the cloud produced by the passage of the rocket.

Certain conclusions can be drawn from this experiment. The rocket technique is an accurate and efficient method of cloud-seeding and compares favourably with seeding by aircraft. It would appear that sodium chloride is an efficient seeding agent in East Africa and that clouds may be induced to rain earlier and more heavily than they would have done naturally. There is strong evidence that clouds which are unlikely to rain naturally can be induced to precipitate by seeding with sodium chloride.

A full report of the experiment is in course of preparation and will be published elsewhere.

J. H. Brazell
C. M. Taylor

East African Meteorological
Department,
Nairobi, Kenya. March 18.

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Surface Hardening of Metals by Spark Discharge

The local hardening of sparked metal is described by Welsh[1] as relying upon transfer from the electrode and/or contamination by the surrounding medium. When discussing these hardening and etching effects in ferrous metals it was mentioned[2] that Rawdon[3] obtained them even when electrolytic iron was sparked *in vacuo* or in argon. In these cases there would be no transfer, and the only contamination might be from any hydrogen in the electrolytic iron.

The recent discoveries that 'whiskers' of iron are crystals containing only one or at most very few dislocations, with consequent high hardness (tensile strength 850 tons/in.^{2})[4] and immunity from etching effects, suggests that sparked iron may contain fewer dislocations than normal.

Hugh O'Neill

Department of Metallurgy,
University College of Swansea.
April 19.

[1] Welsh, N. C., *Nature*, **181**, 1005 (1958).
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[3] Rawdon, H. S., *Trans. Amer. Inst. Min. Met. Eng.*, **70**, 37 (1924); and private discussion (1930).
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Intensity of Remanent Magnetization of Archæological Remains

Two recent contributions referring to the remanent magnetization of archæological material show the need for more experiments. Elsasser, Ney and Winckler raised doubts about the accuracy of dating by radiocarbon[1]. Their argument was that radiocarbon is formed by the action of cosmic rays; that this action is in part governed by the intensity of the Earth's magnetic field; that this intensity varies—

very considerably according to Thellier's study of Roman bricks[2,3]; and that in consequence the initial activity of radiocarbon, from which the age of a specimen is deduced, must vary too. Atwater and Ellickson challenge the premise that Thellier's measurements are valid[4]. They suggest that incomplete combustion in ancient kilns might cause a reducing atmosphere in which the intensity of magnetization would be greatly increased.

Roman kilns, though usually simple, were easily controlled, to judge by their products and an experiment undertaken in October 1956 by F. J. Watson, of Wattisfield, Suffolk[5]. Further, many Roman potters took care about the colour of their pots and bricks, and the colour depends partly on the degree of oxidation and reduction in the firing. The frequent 'terra sigillata' (or 'Samian') pottery of the first three centuries A.D. appears to be a completely oxidized ware; at least, refiring in an electric kiln does not make it redder. So measurements of the intensity of the remanent magnetism of 'terra sigillata' should be reliable. It would be interesting to measure and compare the intensity in the common reduced ware of the same period and so to see if reduction as practised by ancient potters had any effect. Dated specimens of Roman oxidized and reduced wares are plentiful.

If the fears of Atwater and Ellickson prove groundless, then it should be possible to determine the magnetic intensity and from it the initial activity of radiocarbon in the past four or five thousand years, provided of course that the only variable factor in forming radiocarbon is the intensity of the magnetic field of the Earth. At many sites from which radiocarbon dates have been obtained there must also be burnt structures or pottery of almost the same date. These are likely to have a remanent magnetization from which the relevant intensity of the Earth's field could be determined. This was probably implied by Elsasser and his colleagues. But there are at least two problems which also must be examined.

First, it may be that the intensity of remanent magnetism decays slightly with time. Reliable observations of changes in the intensity of the Earth's field go back to about 1830 A.D. Bricks and pots made during this period are plentiful, and for some the date of firing (that is, of the acquisition of remanent magnetism) is known to a year or two. By examining such specimens it should be possible to decide whether the intensity of their remanent magnetization has decayed and, if it has, at what sort of rate.

The second problem is whether the influx of cosmic rays also varies. This might be tested on sites which have both radiocarbon specimens and structures or objects possessing remanent magnetization and which also can be dated precisely by historical records or archæological context. On the assumption that the intensity of remanent magnetism gives the initial activity of radiocarbon, the age of the radiocarbon specimen could be calculated: if this date differs from the known date of the site, then it is likely—so far as present theory goes—that the difference is due to a variation in the influx of cosmic rays and this variation could in turn be calculated.

Because of the 'reservoirs' of radiocarbon in the air and sea, small changes in the formation of radiocarbon might not be detectable, but large or sudden changes should be evident, and with enough samples their magnitude might be determined roughly, but usefully.

I am indebted to Mr. J. C. Belshé and Dr. C. Crowe for directing my attention to the *Nature* communications and for correcting my terminology.

R. M. Cook

Museum of Classical Archaeology,
Cambridge.

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Radiation Hazard from Luminous Watches

In 1956, the Medical Research Council Committee set up to report on the medical aspects of nuclear radiation estimated that luminous watches and clocks increased the population dose of radiation to the gonads by 1 per cent of the natural background[1]. This estimate was based on the assumption that the average wrist-watch contains about one-fifth of a microcurie of radium. Libby[2], reporting a similar investigation, quotes a figure of 1 microcurie of radium per watch as being "perhaps slightly larger than average".

I have recently measured the gamma-ray emission from a modern shock-proof self-winding watch, and estimate that it contains 2·2 microcuries of radium. Measurements on eight other watches collected from colleagues revealed contents ranging from 0·01 to 1·2 microcuries with a mean of about one-quarter of a microcurie. Although, therefore, the figure used by the Committee may be substantially correct, there exist watches containing at least ten times this average amount of radium. Should such watches become more popular with the public, then luminous watches would be second only to diagnostic radiology in the amount of radiation they contribute to the gonads.

With larger amounts of radium a hazard might also arise due to irradiation of the skin immediately under the watch. A film placed in contact with the back of the watch containing 2·2 microcuries recorded a dose-rate of 8 milliroentgens per hr. Assuming the watch to be worn 16 hr. per day, the skin would therefore receive 0·9 roentgen per week, that is, nearly two-thirds of the present maximum permissible level for exposure to limited parts of the body such as hands and forearms[3].

The fact that many luminous watches containing one-fifth of a microcurie or less serve their purpose efficiently casts doubt upon the necessity of using much larger quantities. It therefore seems worthwhile to emphasize two of the conclusions drawn by the Committee[1], namely, that "Adequate justification should be required for the employment of ionizing radiation on however small a scale", and that "The small amounts of irradiation from miscellaneous sources such as X-ray machines used for shoe-fitting, luminous watches and clocks, and television apparatus, should be reduced as far as possible".

J. L. Haybittle

Radiotherapeutic Centre,
Addenbrooke's Hospital,
Cambridge.
April 11.

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[2] Libby, W. F., *Science*, **122**, 57 (1955).
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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, May 19

FARADAY SOCIETY (in D Lecture Theatre, School of Chemistry, The University, Leeds), at 4.30 p.m.—Prof. Walter H. Stockmayer (Massachusetts Institute of Technology): "Configurations and Dynamics of Flexible Macromolecules in Solution" (Bourke Lecture).*

UNIVERSITY OF LONDON (at the London School of Economics and Political Science, Houghton Street, London, W.C.2), at 5 p.m.—Sir Samuel Wadham (Melbourne): "Land Use in Australia".*

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE, PHILOSOPHY OF SCIENCE GROUP (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. W. Grey Walter: "The Study of Complex Systems".

BRITISH COMPUTER SOCIETY (at York Hall, Caxton Hall, London, S.W.1), at 6.15 p.m.—Mr. T. R. Thompson: "Four Years of Automatic Office Work".

Monday, May 19—Friday, May 23

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO AND TELECOMMUNICATION SECTION (at Savoy Place, London, W.C.2)—International Convention on "Microwave Valves".

Tuesday, May 20

UNIVERSITY OF LONDON (at the London School of Economics and Political Science, Houghton Street, London, W.C.2), at 5 p.m.—Mr. B. C. Roberts: "Industrial Relations".* (Last of a series of lectures on "Law and Opinion in England in the Twentieth Century".)

INSTITUTION OF CIVIL ENGINEERS (at Great George Street, London, S.W.1), at 5.30 p.m.—Mr. J. A. Derrington: "Multi-storey Construction in Concrete".

WOMEN'S ENGINEERING SOCIETY, LONDON BRANCH (at the Central Electricity Authority Headquarters, Winsley Street, London, W.1) at 6.45 p.m.—Mr. S. W. Marsh: "Rubber as Applied to General Engineering".

Wednesday, May 21

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 3.30 p.m.—Discussion on "The Dynamical State of the Upper Atmosphere". Opening Speakers: Mr. R. J. Murgatroyd, Mr. J. S. Greenhow, Dr. R. S. Scorer, Mr. J. S. Sawyer and Mr. T. V. Davies.

FARADAY SOCIETY (in the Large Lecture Theatre, Chemistry Department, The University, Manchester), at 4 p.m.—Prof. Walter H. Stockmayer (Massachusetts Institute of Technology): "Configurations and Dynamics of Flexible Macromolecules in Solution" (Bourke Lecture).*

MEDICAL RESEARCH COUNCIL (at the National Institute for Medical Research, Mill Hill, London, N.W.7), at 5 p.m.—Prof. J. Waldenström (University of Lund, Sweden): "The Porphyrias".

BRITISH INSTITUTION OF RADIO ENGINEERS (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Mr. J. H. Beesley: "Cold-Cathode Voltage Transfer Circuits".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. John C. Kendrew: "The Architecture of a Protein Molecule".

Thursday, May 22

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Prof. P. B. Medawar, F.R.S.: "The Homograft Reaction" (Croonian Lecture).

UNIVERSITY OF LONDON (at Charing Cross Hospital Medical School, Chandos Place, London, W.C.2), at 5.30 p.m.—Sir Howard Florey, F.R.S.: "The Changing Emphasis in Medical Research"* (Huxley Lecture for 1958).

UNIVERSITY OF LONDON (in the Chemistry Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. D. McKie: "Science and History"* (Inaugural Lecture).

UNIVERSITY OF LONDON (at Wye College, near Ashford, Kent), at 8.15 p.m.—Sir Samuel Wadham (Melbourne): "Science and Agriculture in Australia".*

Saturday, May 24

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 11 a.m.—Anniversary Meeting.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER IN ORGANIC CHEMISTRY, a LECTURER IN BIOLOGY, and an ASSISTANT (Grade B) IN GENERAL CHEMISTRY at Birkenhead Technical College—The Director of Education, Birkenhead Education Committee, 63 Hamilton Square, Birkenhead (May 21).

LECTURER (graduate, and/or A.M.I.E.E., and preferably with teaching and/or industrial experience) IN ELECTRICAL ENGINEERING at Brighton Technical College, to teach a specialist subject in any branch of electrical engineering to final degree or equivalent standard—The Director of Education, County Borough of Brighton Education Committee, 54 Old Steine, Brighton (May 23).

ASSISTANT, Grade B (with a good special degree in zoology and previous experience in teaching), TO TEACH ZOOLOGY to the level of G.C.E. Advanced Level—The Principal, Acton Technical College, High Street, Acton, London, W.3 (May 24).

RESEARCH ASSISTANT (with an honours degree in either mining, physics, mathematics or chemical engineering, and with research experience in one of these subjects) IN THE DEPARTMENT OF MINING AND FUELS—The Registrar, The University, Nottingham (May 26).

LECTURER IN PHYSIOLOGY—The Registrar, King's College, Strand, London, W.C.2 (May 30).

READER IN APPLIED MATHEMATICS—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (May 30).

SENIOR LECTURER or LECTURER (with a good honours degree and teaching experience) IN PHYSICS at the Nigerian College of Arts, Science and Technology—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (May 30).

ASSISTANT KEEPER (GEOLOGY) (preferably with a university degree in geology and prepared to become a registered student for the Diploma of the Museums Association)—The Director, Museums and Art Gallery, New Walk, Leicester (May 31).

ASSISTANTS (2) IN CHEMISTRY (one physical and one organic)—The Secretary, The University, Aberdeen (May 31).

DIRECTOR (with a medical or scientific qualification and experience in entomology, helminthology or parasitology, both in the laboratory and in the projection of such work into the field, and preferably experience in administering research programmes both in the field and in the laboratory) OF THE RESEARCH LABORATORY, Federal Ministry of Health, Salisbury, Southern Rhodesia, for work chiefly devoted to the study of malaria and its control and the study of bilharziasis in all its aspects—The Secretary (R), Rhodesia House, 429 Strand, London, W.C.2 (May 31).

LECTURER or ASSISTANT LECTURER IN PHYSIOLOGY—The Registrar, The University College of South Wales and Monmouthshire, Cathays Park, Cardiff (May 31).

READER (with high academic qualifications, good experience in teaching and research, and preferably industrial experience) IN PHYSICAL METALLURGY—The Clerk to the Governing Body, Battersea College of Technology, London, S.W.11 (May 31).

RESEARCH ASSISTANT IN NUMERICAL ANALYSIS IN THE DEPARTMENT OF APPLIED MATHEMATICS—The Registrar, The University, Liverpool (June 4).

LECTURER IN MATHEMATICS—The Provost, Oriel College, Oxford (June 7).

UNIVERSITY STUDENTS AND FELLOWS, for experimental or theoretical research in solid state physics—The Professor of Natural Philosophy, The University, Glasgow, W.2 (June 7).

SENIOR LECTURER IN PHYSICS at the University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, June 16).

CHIEF LECTURER IN VETERINARY PATHOLOGY, a LECTURER IN PSYCHOLOGY, a LECTURER IN CHEMISTRY, and a LECTURER IN VETERINARY PARASITOLOGY at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, June 30).

SCIENTIFIC OFFICER (graduate (good honours), preferably with two or three years postgraduate experience) IN THE ENTOMOLOGY DEPARTMENT, to work on some problems concerning the biology of forest soils—The Secretary Rothamsted Experimental Station, Harpenden, Herts (June 30).

LECTURER IN MATHEMATICS at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, July 15).

PROFESSOR OF GEOGRAPHY at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, July 31).

ASSISTANT (preferably with an interest in physical methods of analysis and instrumentation), for research on the mode of action of anti-tuberculosis drugs—The Secretary, Guy's Hospital Medical School, London Bridge, S.E.1.

GRADUATE RESEARCH ASSISTANT (Senior or Junior) (with a good degree in physiology or zoology and preferably with a sound background in physics), to work with a small team concerned with the effects of ionizing radiation on physiological systems and on experimental tumours—The Administrative Officer, Christie Hospital and Holt Radium Institute, Manchester 20.

LECTURER (with a higher degree and research interests in organic chemistry) IN CHEMISTRY—The Secretary, Sir John Cass College, Jewry Street, London, E.C.3.

PHYSICISTS (with an honours degree or equivalent qualification and preferably experience in one or more branches of non-destructive testing) AT THE RESEARCH LABORATORIES, Leatherhead, Surrey, for research into the non-destructive testing of all types of materials used in the electricity supply industry—The Chief Personnel Officer, Central Electricity Generating Board, 24–30 Holborn, London, E.C.1, quoting Ref. N/127, marking envelope "Confidential".

READER (with a degree in chemical engineering, chemistry or engineering, and Corporate Member of the Institution of Chemical Engineers) IN CHEMICAL ENGINEERING—The Registrar, Loughborough College of Technology, Loughborough, quoting 18/G.

RESEARCH ASSISTANT (with, or candidate for, the B.Sc. (Special Chemistry) Degree of the University of London) IN CHEMISTRY, to work for a higher degree on a physicochemical project approved by the Head of the Department—The Registrar, Brighton Technical College, Brighton.

SCIENTIFIC OFFICER (with a recent honours degree in chemistry or biochemistry) IN THE ISOTOPE SECTION, for work which involves the application of isotope tracer techniques to fundamental biological

research—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, Berks, quoting Ref. No. 58/12.

Senior Lecturer, an Assistant Lecturer (Grade B), and a Research Assistant in the Department of Mathematics—The Secretary, Sir John Cass College, Jewry Street, London, E.C.3.

Technician in the Department of Bacteriology—The Secretary, University College Hospital Medical School, University Street, London, W.C.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Chemical Engineering in a University. By Prof. P. V. Danckwerts. (Inaugural Lecture, 12 November 1957.) Pp. ii+10+4 plates. (London: Imperial College of Science and Technology (University of London), 1958.) 5s. [242

University of Sheffield. Report on Research work carried out in the Department of Fuel Technology and Chemical Engineering during the Period April, 1954–April, 1957. Pp. iii+30. (Sheffield: The University, 1958.) [242

Northampton Polytechnic, London. Prizes and Certificates, Session 1956–57. Pp. 32. (London: Northampton Polytechnic, 1958.) [242

Ministry of Agriculture, Fisheries and Food. Fishery Investigations. Series 2, Vol. 21, No. 7: The Laverbread Industry in South Wales and the Laverweed. By M. A. Hampson. Pp. iii+8+plate 1. (London: H.M. Stationery Office, 1957.) 4s. net. [242

Library Association Pamphlet No. 18: Archives and Manuscripts in Libraries. By Philip Hepworth. Pp. 30. (London: The Library Association, 1958.) 5s. [242

Flora of Tropical East Africa. Edited by Dr. W. B. Turrill and E. Milne-Redhead. Alangiaceae. Pp. 4. 1s. Polygonaceae. Pp. 40. 3s. (London: Crown Agents for Overseas Governments and Administrations, 1958.) [242

The Plastics Industry Education Fund. Second Progress Report, 1955–1957. Pp. 11. (London: The Plastics Institute, 1958.) [242

University of Birmingham. University Research Committee Twenty-eighth Annual Report, Session 1956–1957. Pp. 107. Accounts for the year ended 31st July, 1957. Pp. 35. Report of the Proceedings of the Council of the University for the year ended 31st December, 1957. Pp. 17. Report of the Vice-Chancellor and Principal for the calendar year 1957. Pp. 26. (Birmingham: The University 1957 and 1958.) [242

Applied Mechanics in Engineering. By Prof. R. E. D. Bishop. (An Inaugural Lecture delivered at University College, London, 23 January, 1958.) Pp. 24+7 figures. (London: H. K. Lewis and Co., Ltd., 1958. Published for the College.) 2s. 6d. net. [242

University of Leeds. Annual Report of the Librarian, Session 1956–57. Pp. 12. (Leeds: The Brotherton Library, The University, 1957.) [242

British Museum (Natural History). Economic Series, No. 4A: British Mosquitoes and their Control. Fourth Edition. Pp. 23. 1s. Bulletin of the British Museum (Natural History). Mineralogy. Vol. 1, No. 5: Petrological Studies in Glen Urquhart, Inverness-shire. By G. H. Francis. Pp. 121–162+plates 8–10. 15s. Geology. Vol. 3, No. 4: The Structure of Some Leaves and Fructifications of the *Glossopteris* Flora of Tanganyika. By Divya Darsham Pant. Pp. 125–175+plates 18–21. 21s. Vol. 3, No. 5: *Lidgettonia*, a new Type of Fertile *Glossopteris*. By H. Hamshaw Thomas. Pp. 177–189+plates 22 and 23. 5s. (London: British Museum (Natural History), 1958.) [242

Field Studies Council. Annual Report, 1956–1957. Pp. 68+8 plates. (London: Field Studies Council, 1958.) [242

Department of Scientific and Industrial Research: Building Research Station. National Building Studies. Research Paper No. 23: Condensation in Sheeted Roofs. By A. W. Pratt. Pp. iv+40+12 plates. (London: H.M. Stationery Office, 1958.) 3s. 6d. net. [242

Science for the Informal Group. Pp. iv+20. (London: Science Club.) [242

British Electrical and Allied Industries Research Association. Technical Report L/T 341: Reverse Driving of Short Arcs. By A. E. Robson. Pp. 4+5 figures. 6s. Technical Report N/T74: Some Magnetic Properties of Dilute Anisotropic Ferromagnetic Alloys. By Prof. W. Sucksmith. Pp. 7+1 figure. 6s. (Leatherhead: British Electrical and Allied Industries Research Association, 1956.) [242

Aero Research Technical Notes. Bulletin No. 182 (February, 1958): Vehicle Body Building. Pp. 10. (Duxford: Aero Research, Ltd., 1958.) [242

The Physical Society. Handbook of Scientific Instruments and Apparatus, 1958. (Published in connection with the 42nd Physical Society Exhibition, London, March 24–27, 1958.) Pp. xvi+284+84. (London: The Physical Society, 1958.) 6s. [242

Report of the Proceedings of the 1957 Conference of the Universities of the United Kingdom, convened by the Committee of Vice-Chancellors and Principals, and held in the William Beveridge Hall, University of London Senate House on 13th and 14th December, 1957. Pp. 111. (London: Association of Universities of the British Commonwealth, 1958.) 5s. [242

Other Countries

Berichte des Deutschen Wetterdienstes. Nr. 41: Meteorologische Messgeräte und Voraussetzungen für den Schorfwarndienst. Von Fritz Schnelle und Wilhelm Breuer. Pp. 22. 3.40 D.M. Nr. 42: Diagramme zum Strahlungsklima Europas. Zusammengestellt von Wolfgang Collman. Pp. 8 mit 3 tabellen im text und 20 tafeln. (Offenbach/M.: Deutschen Wetterdienstes, 1958.) [242

Canada: Department of Mines and Technical Surveys. Publications of the Dominion Astrophysical Observatory, Victoria, B.C. Vol. 10, No. 16: The Spectrographic Orbit of H.D. 123299, Alpha Draconis. By Joseph A. Pearce. Pp. 331–340. 25 cents. Vol. 10, No. 17: Spectrographic Observations at the 1953 and 1955–56 Eclipses of Zeta Aurigae. Pp. 341–348+plates 22 and 23. n.p. (Ottawa: Queen's Printer, 1957.) [242

Kungl. Svenska Vetenskapsakademiens Handlingar. Fjärde Serien. Band 6, Nr. 6: Die Gewässer des Abisko-Gebietes und ihre Bedingungen. Von Sven Ekman. Pp. 172. 24 Kr. Band 6, Nr. 7: Taxonomical and Ecological Studies on Planktonic Rotatoria from Central Sweden. By Birger Pejler. Pp. 52. 9 Kr. (Stockholm: Almqvist and Wiksell, 1957.) [242

U.S. Department of Agriculture. Technical Bulletin No. 1172: Effect of Some Crop Rotations on Wireworm Populations in Irrigated Lands. By K. E. Gibson, M. C. Lane, W. C. Cook and E. W. Jones. Pp. ii+19. (Washington, D.C.: Government Printing Office, 1958.) 15 cents. [242

Union of South Africa: Department of Commerce and Industries. Twenty-Seventh Annual Report for the period 1st April, 1955 to 31st March, 1956. By Dr. J. M. Marchand. Pp. 159+3 plates. (Reprint from *Commerce and Industry*, July, 1957.) Investigation Report No. 29: The South African Pilchard (*Sardinops ocellata*) and Maasbanker (*Trachurus trachurus*). Young Fish Survey, 1955–56. By Dr. D. H. Davies. Pp. 36. (Reprint from *Commerce and Industry*, October 1957.) (Pretoria: Government Printer, 1957.) [242

National Museum of Victoria, Melbourne. Memoirs. No. 22, Part 5, (14th June, 1957): The Devonian Foraminifera from Tamworth, New South Wales. By Alan Wood. Pp. 4 (1 plate). No. 22, Part 6 (26th August, 1957): Life History of *Heteronympha cordace cordace* Hubner. By A. N. Burns. Pp. 3 (1 plate). No. 22, Part 7 (4th September, 1957): Drum Types of Eastern New Guinea. By Aldo Massola. Pp. 12 (2 plates.) (Melbourne: National Museum of Victoria, 1957.) [242

Commonwealth Scientific and Industrial Research Organization, Australia. Soil Publication No. 9: Investigations into the Nature of Soil *p*H. By M. Raupach. Pp. 35. (Melbourne: Commonwealth Scientific and Industrial Research Organization, 1957.) [242

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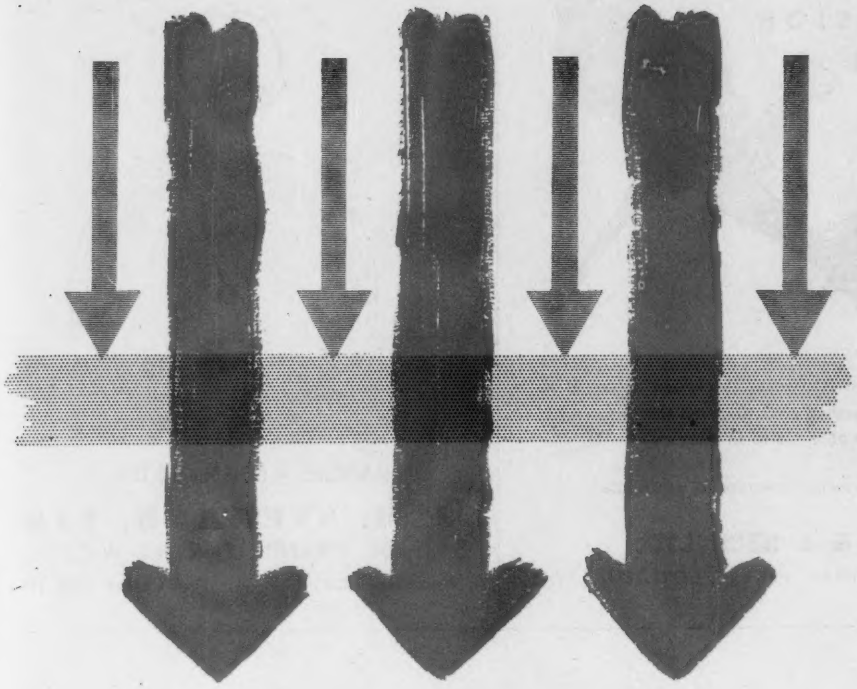

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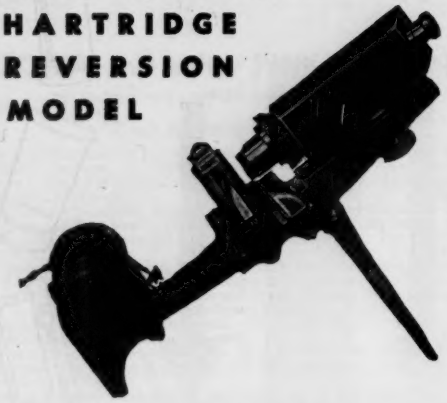

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